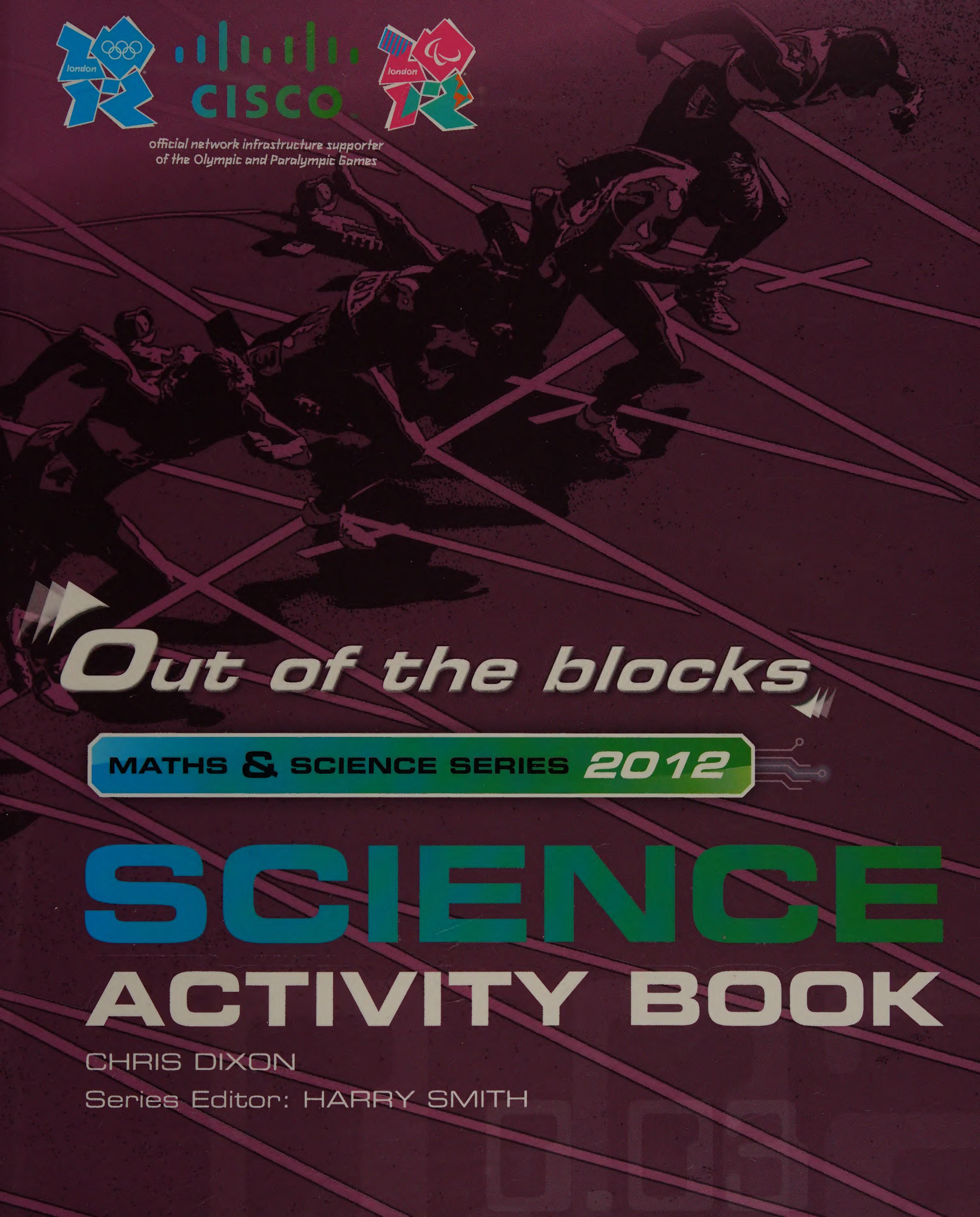




official network infrastructure supporter
of the Olympic and Paralympic Games



Out of the blocks

MATHS & SCIENCE SERIES *2012*

SCIENCE ACTIVITY BOOK

CHRIS DIXON

Series Editor: HARRY SMITH

MATHS & SCIENCE SERIES 2012

SCIENCE ACTIVITY BOOK

CHRIS DIXON

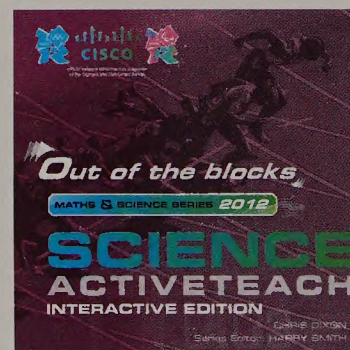
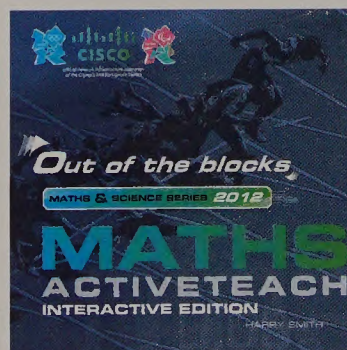
Series Editor: HARRY SMITH

Cisco - official Network Infrastructure supporter of the
London 2012 Olympic and Paralympic Games

www.mathsandscience2012.co.uk

Go online for the interactive editions of both the Maths and Science Activity Books,
along with video clips and other features.

- Open access - no registration required
- Interactive editions hosted on our ActiveTeach platform (see page 11)
- Video interviews with Olympic Competitors
- Worksheets and answers
- Details of our Maths and Science Challenge 2012 (see page 11)



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Original illustrations © Pearson Foundation 2012
Cover photo/illustration © **Corbis**: epa/Gero Breloer

First published 2012

16 15 14 13 12

10 9 8 7 6 5 4 3 2 1

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN 978 1 447 90434 2

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Published by the Pearson Foundation, Halley Court, Jordan Hill, Oxford, OX2 8EJ

Printed in the UK by Scotprint

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Acknowledgements

The authors and publisher would like to thank the following individuals and organisations for permission to reproduce photographs:

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The publisher gratefully acknowledges the contribution of the **Ellen MacArthur Foundation** in supporting this publication. The Ellen MacArthur Foundation is a registered charity with the aim of inspiring a generation to re-think, re-design and build a positive future.
www.ellenmacarthurfoundation.org

The publisher gratefully acknowledges the contribution of the **Happold Trust** in supporting this publication. The Happold Trust is a charity established by Buro Happold Consulting Engineers to promote education, research and training in all areas relating to the built environment.

The publisher gratefully acknowledges the contribution of the **Lee Valley Regional Park Authority** in supporting this publication.

The publisher gratefully acknowledges the contributions of Sue Kearsey and of Ashwell Enterprises Limited in reviewing the science content.

Disclaimer

The author and publisher have made every effort to ensure that this book is factually correct at the time of writing. However, due to the nature of an event such as London 2012, some details will be subject to change.

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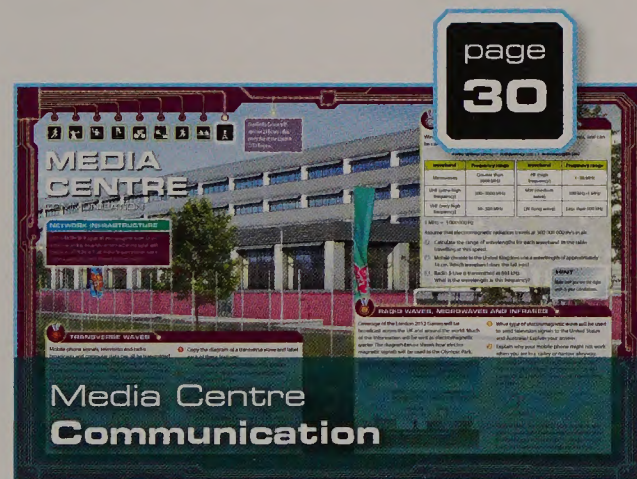
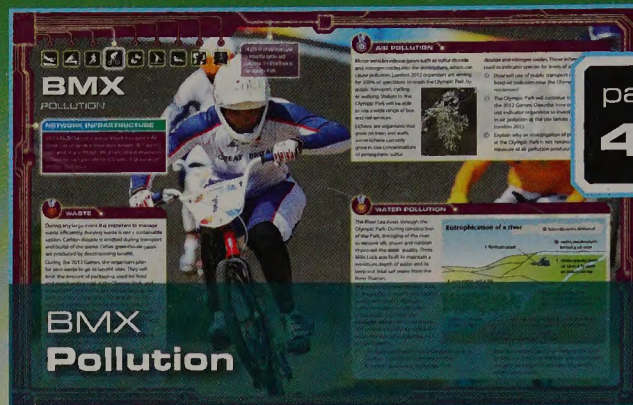
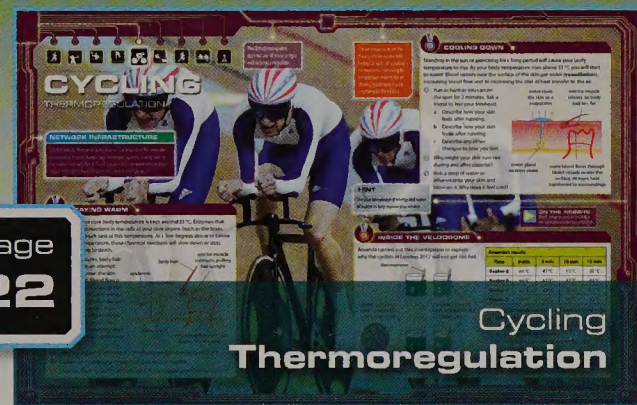
A FUTURE IN MATHS AND SCIENCE

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CONTENTS AT A GLANCE

1 VENUES IN THE OLYMPIC PARK

Take a tour of the Olympic Park with the science activities in this book.



NETWORK INFRASTRUCTURE

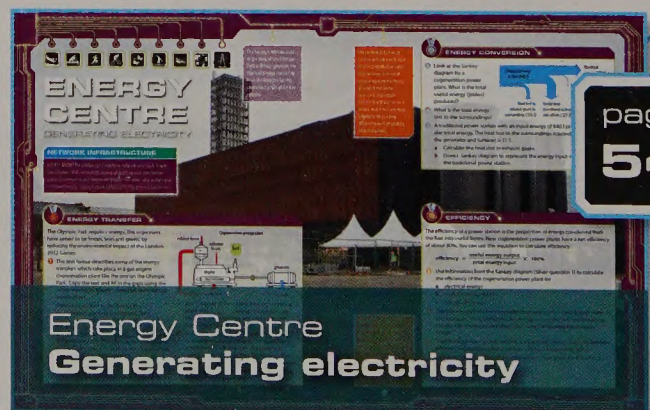
During the London 2012 Games, there could be more than 200 000 people in the Olympic Park at any time, texting, tweeting and checking the latest results on their phones.

On top of that, thousands of officials, journalists, security officers and athletes need to be able to communicate quickly and reliably.

Cisco, which is the official network infrastructure supporter for London 2012, has networked more than 100 locations for the London 2012 Games, making sure that everyone can stay in touch and stay connected.



Outdoor wireless access points like this one can withstand winds of up to 165 mph.



SYNCHRONISED SWIMMING

ENERGY TRANSFER BY HEATING

NETWORK INFRASTRUCTURE

The swimming pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

COOLING WATER

The swimming pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

WRITING CONCLUSIONS

Write a conclusion about the energy transfer by heating in the swimming pools at the Aquatics Centre.

DIVING

CARBON DATING

NETWORK INFRASTRUCTURE

The diving boards at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

COOLING WATER

The swimming pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

WRITING CONCLUSIONS

Write a conclusion about the energy transfer by heating in the swimming pools at the Aquatics Centre.

WATER POLO

HEATING AND INSULATING BUILDINGS

NETWORK INFRASTRUCTURE

The water polo pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

COOLING WATER

The swimming pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

WRITING CONCLUSIONS

Write a conclusion about the energy transfer by heating in the swimming pools at the Aquatics Centre.

LEGACY AND SUSTAINABILITY

THE OLYMPIC STADIUM

NETWORK INFRASTRUCTURE

The Olympic Stadium at the Aquatics Centre is incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

COOLING WATER

The swimming pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

WRITING CONCLUSIONS

Write a conclusion about the energy transfer by heating in the swimming pools at the Aquatics Centre.

DECATHLON

METALS AND THEIR USES

NETWORK INFRASTRUCTURE

The decathlon events at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

COOLING WATER

The swimming pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

WRITING CONCLUSIONS

Write a conclusion about the energy transfer by heating in the swimming pools at the Aquatics Centre.

100m SPRINT

NEURONES AND SIGNALS

NETWORK INFRASTRUCTURE

The 100m sprint events at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

COOLING WATER

The swimming pools at the Aquatics Centre are incredibly energy efficient. The water is heated by a system of heat exchangers that transfer heat from the water in the pools to the water in the pools. This system is called a 'heat recovery system'.

WRITING CONCLUSIONS

Write a conclusion about the energy transfer by heating in the swimming pools at the Aquatics Centre.



CONTENTS AT A GLANCE

2 VENUES OUTSIDE THE OLYMPIC PARK

Check out some of the London 2012 venues around London and the rest of the UK with these science activities.



MARATHON

Marathon Respiration

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GYMNASTICS

Gymnastics Genes and inheritance

page 48

Wembley Arena

Wembley Stadium

Lord's Cricket Ground

Olympic Park

Hyde Park

The Mall

North Greenwich Arena

ExCeL

Earl's Court

Horse Guards Parade

Royal Artillery Barracks

Greenwich Park

Wimbledon

Hampton Court

page 38

BEACH VOLLEYBALL

Beach Volleyball Structure and bonding

page 52

PENTATHLON

Pentathlon Electrical circuits

page 16

PARALYMPIC ARCHERY

Paralympic Archery Motion and forces

LIVE SITES

During the 2012 Games, 20 big screens will be in operation throughout the country, showing news, highlights and live action from London 2012. 20-foot LCD screens will mean spectators can be right at the heart of the action and excitement. Supported by Cisco, these sites were just one of the ideas which organisers of the Vancouver 2010 Winter Games shared with London 2012.



Spectators in Belfast enjoy big screen tennis action live from Wimbledon.



Live Site locations in the UK. Which one is nearest to you?

SPECIFICATION MATCHING CHART

ENGLAND

PAGES	EVENT / SCIENCE TOPIC		SCIENCE CONTENT	AQA A	AQA B	EDEXCEL	OCR A
14–15	100 m SPRINT neurones and signals		myelinated neurones, synapses, reflex arcs	B1.2.1	3.4.1.1	B1 topic 2	B6 topic B6.2
16–17	PARALYMPIC ARCHERY motion and forces		force, velocity and acceleration	P2.1.2	N/A	P2 topic 3	P4 topic P4.1
18–19	WATER POLO heating and insulating buildings		minimising heat loss	P1.1.1, 1.1.4	3.5.3.2	P1 topic 6	P2 topic P2.1
20–21	DIVING carbon dating		carbon dating, half-life, beta decay	P2.5.2	N/A	P2 topic 6	P6 topic P6.1
22–23	CYCLING thermoregulation		vasoconstriction, vasodilation, rates of cooling	B3.3.2	3.4.1.11	B1 topic 2	B7 topic B7.3
24–25	SAILING polymers		polymer structure and formation, testing polymers	C1.5.2	3.4.2.1	C1 topic 5	C2 topic C2.2, C2.3
26–27	DECATHLON metals and their uses		iron, alloys of iron, carbon steel	C1.3.2	3.3.1.4	C1 topic 4	N/A
28–29	ROWING diabetes		blood glucose concentration, type 1 diabetes, insulin	B3.3.3	3.4.1.1	B1 topic 2	B7 topic B7.3
30–31	MEDIA CENTRE communication		radio waves, microwaves, optical fibres	P1.5.1, 1.5.2	3.4.3.2	P1 topic 1, topic 2	P1 topic P1.2; P2 topic P2.4
38–39	BEACH VOLLEYBALL structure and bonding		electronic configuration, covalent molecules, giant molecular structures	C2.1.1, 2.2.3	N/A	C2 topic 3	C5 topic C5.3
40–41	CANOE SPRINT diet and exercise		energy in food, metabolic rate, energy consumption	B1.1.1	N/A	N/A	N/A
42–43	MARATHON respiration		aerobic respiration, anaerobic respiration, effects of exercise	B2.6.1, 2.6.2	N/A	B2 topic 2	B4 topic B4.3
44–45	BMX pollution		waste, air pollution, water pollution	B1.4.2	3.5.3.1	B1 topic 3	B3 topic B3.1
46–47	SYNCHRONISED SWIMMING energy transfer by heating		specific heat capacity, cooling, convection currents	P1.1.4	N/A	P1 topic 6	N/A
48–49	GYMNASTICS genes and inheritance		variation, alleles, genotypes	B1.7.1, 2.7.2	B2.7.2	B1 topic 1	B1 topic B1.1, B1.2
50–51	PARALYMPIC ROAD CYCLING energy transfers		work done, power, potential energy, kinetic energy	P2.2.1	N/A	P1 topic 6, P2 topic 4	P4 topic P4.4
52–53	PENTATHLON electrical circuits		circuits, current, resistance, voltage and charge	P2.3.2, P2.4.2	N/A	P2 topic 2	P5 topic P5.2
54–55	ENERGY CENTRE generating electricity		energy transfer, energy conversion, efficiency	P1.2.1, 1.3.1, 1.4.1	3.4.3.1	P1 topic 5, topic 6	P3 topic P3.1, P3.2

	WALES	N. IRELAND	SCOTLAND			
OCR B	Y10	CCEA	High School / Intermediate 2	CFE	EVENT / SCIENCE TOPIC	PAGES
B1 item B1d	B1 6a	B1.6.5, 1.6.6	B Int 2 unit 3	SCN 4-12a	100 m SPRINT neurones and signals	 14–15
P3 item P3b, 3c	P2 2a, 2b, 2c, 3a, 3b, 3c, 3d, 3e, 3f	P1.1.4, 1.1.9	P Int 2 unit 1	SCN 4-07a, 4-07b	PARALYMPIC ARCHERY motion and forces	 16–17
P1 item P1a	P1 4e, 4f	N/A	SG P6.4	SCN 3-04a	WATER POLO heating and insulating buildings	 18–19
P4 item P4e	P2 5b, 5d, 6a	P1.4.7, 1.4.14	P Int 2 unit 4.3; SG P3.5	N/A	DIVING carbon dating	 20–21
B1 item B1f	B1 6d, 6g	N/A	B Int 2 unit 3	SCN 4-12a	CYCLING thermoregulation	 22–23
C1 item C1d	C1 6e, 6f, 6g	C 2.8.12, 2.8.13, 2.8.14 (2.6.15, 2.6.16, 2.6.17)	C Int 2 unit 2	SCN 4-16a	SAILING polymers	 24–25
C2 item C2c	C1 3l; C2 3b	C 1.7.7, 1.7.8 (1.4.8, 1.4.9)	C Int 1 unit 2	SCN 4-15a	DECATHLON metals and their uses	 26–27
B1 item B1f	B1 6e, 6f, 6h	B 1.8.4 (1.6.11)	N/A	N/A	ROWING diabetes	 28–29
P1 item P1c, P1d, P1f, P1g	P1 5a, 5b, 5d, 5h	P 2.1.2, 2.1.6, 2.1.14	P Int 1 unit 1, P Int 2 unit 3; SG P1	SCN 3-11b, 4-11b	MEDIA CENTRE communication	 30–31
C4 item C4a, 4c	C2 3a, 3e	C 1.5.1, 1.6.6, 1.6.7, 1.7.3 (1.2.2, 1.3.6, 1.3.7, 1.4.4)	C Int 2 unit 1; SG C4	N/A	BEACH VOLLEYBALL structure and bonding	 38–39
B1 item B1b	B1 7a	B 1.3.5, 1.3.6, 1.3.7	B Int 1 unit 1, B Int 2 unit 1; SG B5b	N/A	CANOE SPRINT diet and exercise	 40–41
B3 item B3c	B2 4c, 4d	B 1.7.3, 1.7.4 (1.5.8)	N/A	SCN 3-12a	MARATHON respiration	 42–43
B2 item B2g	B1 1c, 1e	B 1.3.1, 1.3.4	SG Science 4.5; SG B1c	N/A	BMX pollution	 44–45
N/A	N/A	N/A	P Int 2 unit 1.4; SG P6.4	N/A	SYNCHRONISED SWIMMING energy transfer by heating	 46–47
B1 item B1h	B1 3a, 3g, 4a	B 2.5.6 (2.3.12, 2.6.1)	B Int 2 unit 2; SG B6	SCN 4-14c	GYMNASTICS genes and inheritance	 48–49
P3 item P3d, P3e	P2 4b, 4c, 4d, 4e	P 1.2.7, 1.2.8, 1.2.10	P Int 2 unit 1.3	N/A	PARALYMPIC ROAD CYCLING energy transfers	 50–51
P4 item P4c	P2 1b, 1c, 1e, 1f	P 2.2.5, 2.2.10, 2.2.25	P Int 1 unit 2.2, P Int 2 unit 2.1, 2.2; SG P2.3	SCN 4-09a	PENTATHLON electrical circuits	 52–53
P2 item P2b	P1 4a, 4c, 4d	P 1.2.1, 1.2.2, 1.2.4	SG P6.2	SCN 4-04a, 4.04b	ENERGY CENTRE generating electricity	 54–55

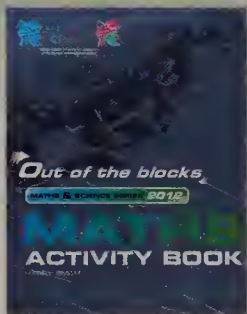
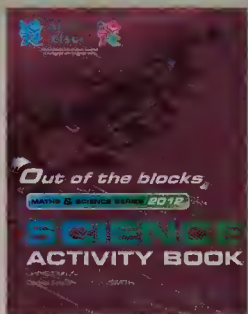
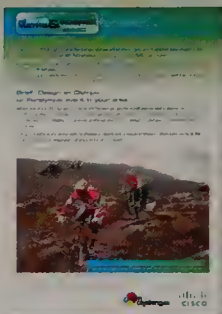
MATHS AND SCIENCE SERIES 2012

The London 2012 Olympic and Paralympic Games will be the largest sporting event ever staged in the UK. Without the science skills of its organisers, engineers and architects, none of it would be possible.

The *Maths and Science Series 2012* gives you the chance to find out more about the events and venues of London 2012, whilst practising maths and science skills. The full range of free resources available in the series is listed in the table below.

TIPS FOR TEACHERS CURRICULUM

To see how the contents of this book map onto the GCSE and SCQF curriculums, turn to page 8. Here you will find mappings to the most popular specifications in England, Scotland, Wales and Northern Ireland.

Print resources	Online resources www.mathsandscience2012.co.uk	Challenge 2012
 	 	
The Activity Books will help bring London 2012 to life in the classroom. 15 copies of the Maths Activity Book and 15 copies of the Science Activity Book will be sent to every state-funded Secondary school in the UK.	The Maths and Science ActiveTeach can be accessed for free on our website. As well as having an electronic version of the book, the ActiveTeach contains great videos, and lots of helpful teaching resources.	The Maths and Science Challenge 2012 is a project-based competition open to all UK state-funded Secondary schools. It gives students the chance to imagine what a major sporting event might look like in their area.

Using your Science Activity Book

The Science Activity Book has been designed for Key Stage 4. It targets GCSE grades C and D, so it covers science that all students need for their exams.

Bronze, Silver and Gold activities on each double-page spread offer stepped questions around the same science topic. Bronze activities should take about 10 minutes to complete, and test basic skills and knowledge. Silver and Gold activities should take about 15–20 minutes to complete, testing problem-solving ability.

Scientific topics are clearly labelled so you can make sure you're ready to tackle each section

Network infrastructure boxes highlight the maths and science skills Cisco engineers used to network the London 2012 Games

Straightforward Bronze activities are a great way to get started



Stacks of facts about venues, events and athletes

Silver activities are a bit more challenging, but still use science skills familiar to students

Links to videos on the website

Gold activities provide an opportunity for students to test the problem-solving skills they'll need in their exams

Using your Science ActiveTeach

The Science ActiveTeach is the e-book edition of your Science Activity Book. As well as having an electronic version of the book, the ActiveTeach also contains high-impact videos. You can access the ActiveTeach online at www.mathsandscience2012.co.uk/activeteach. It's free and straightforward to use, with no registration or password needed.

You can also display the ActiveTeach on a classroom whiteboard. You can zoom into key areas of the book, and explore the video clips using direct links from the page.

TIPS FOR TEACHERS

WORKSHEETS AND ANSWERS ON ACTIVETEACH

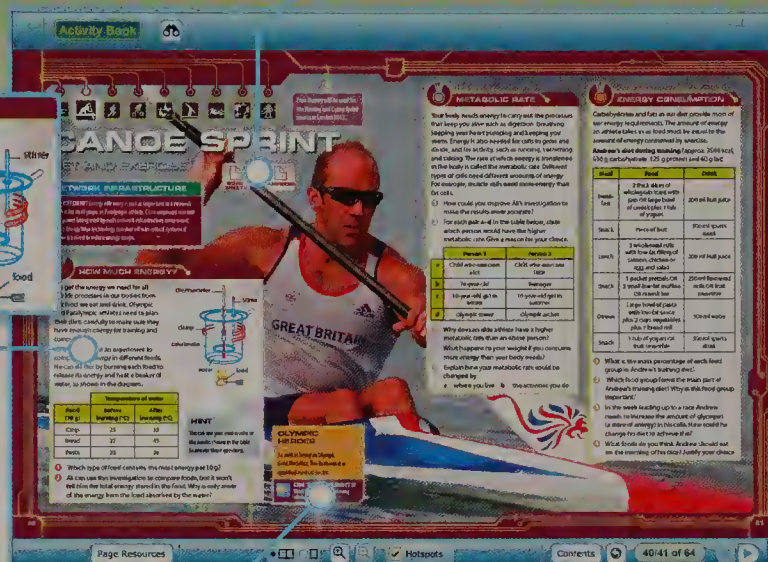
Click on the icons at the top of any double-page spread to access worksheets and answers.



Zoom areas make it easy to focus on a specific activity



Direct links to videos engage students and enrich lessons



Maths and Science Challenge 2012

The Maths and Science Challenge 2012 gives students the chance to design a major sporting event in their area. Teams choose an event and a venue, then solve some of the problems facing the organisers of any London 2012 event. Every entry will include a short video, giving students a chance to explain their great ideas and brilliant maths and science skills.



Could the mountain biking be hosted in your area?

The best eight teams in the country will come to Cisco House, overlooking the Olympic Park in London, to battle it out for the top prizes – London 2012 tickets! In addition, winning teams will receive cash prizes for their STEM Club and London 2012 merchandise.

The competition is being run in association with STEMNET as STEM Challenge 10.

So get a team together and get planning!

TIPS FOR TEACHERS

ENTERING A TEAM

The Maths and Science Challenge 2012 is open to teams of 4 to 6 students aged 16 and under, and should take between 8 and 16 hours to complete.

Full details, including activities, factsheets and support materials can be found on the website at

www.mathsandscience2012.co.uk/challenge2012

Cisco

Official network infrastructure supporter of the London 2012 Olympic and Paralympic Games

The *Maths and Science Series 2012* has been proudly supported by Cisco, the official network infrastructure supporter of the London 2012 Olympic and Paralympic Games.

Cisco has provided the digital network infrastructure which will help enable pictures, video and results from every London 2012 event and venue to be shared with the rest of the world.

Cisco's network infrastructure for London 2012 will allow athletes, organisers, journalists and spectators to interconnect, access key London 2012 time applications, and connect to the internet at super-fast speeds, using either wired connections in over 100 London 2012 venues or wi-fi coverage throughout the venues and Olympic Park.

Cisco began life in 1984 in San Francisco, USA, when a married couple working at Stanford University designed a router which allowed computers made by different manufacturers to talk to each other. It took its name from the city where it was founded.

Now Cisco operates around the world and employs over 60 000 people. Since it began, the company has revolutionised the speeds at which digital data can be sent, has enabled millions of people to access the internet wirelessly, and has pioneered new technologies for video conferencing. Without Cisco's technologies, social networking, online gaming and downloading music and video wouldn't be possible.

Maths and science are at the heart of computing and networking, and the skills you practise in this book could one day help you design the next world-changing social network, or ground-breaking internet technology.



Cisco's 2 metre-tall CR-3 router forms part of the backbone of the internet. Using a 40-core low power QuantumFlow processor, this beast can transmit 322 terabits of data every second. That's enough bandwidth to stream 16 million high definition videos simultaneously!

Network infrastructure

Throughout this book we'll be showing you how Cisco's network infrastructure will play a crucial role in the smooth running of the London 2012 Games. You'll also learn about some of the science involved in setting up and running a high-speed network. Just look for the network infrastructure fact boxes like this one.

NETWORK INFRASTRUCTURE

DID YOU KNOW? Cisco's network infrastructure at London 2012 is capable of transmitting over 10 GB of information each second. In the time it takes Usain Bolt to run the 100 m you could download the entire contents of Wikipedia. Twice.

www.mathsandscience2012.co.uk

Go online for the interactive editions of both the Maths and Science Activity Books, along with video clips and other features.

Out of the blocks

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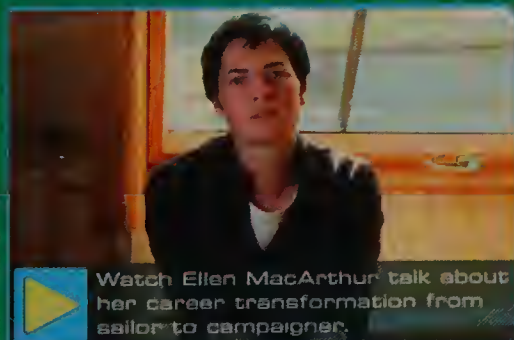
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[Sustainable Velodrome wins Better Public Building Award](#)

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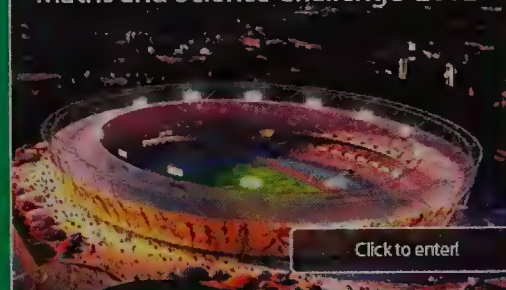
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100m SPRINT

NEURONES AND SIGNALS

NETWORK INFRASTRUCTURE

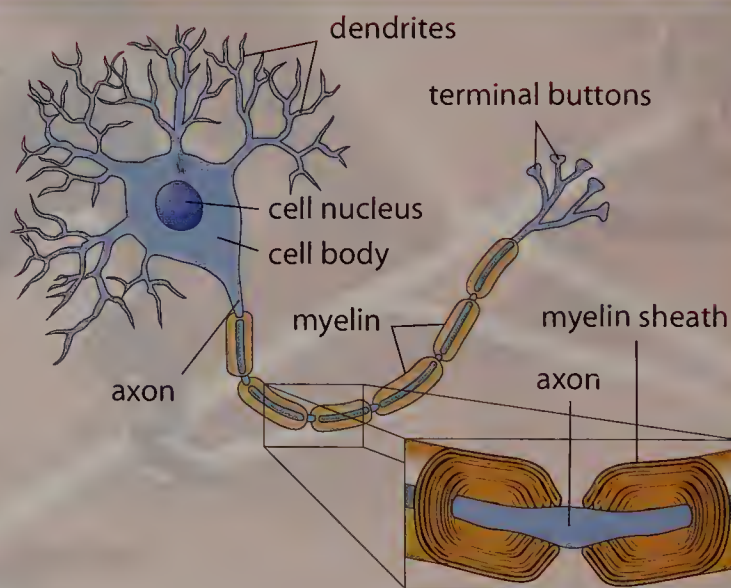
DID YOU KNOW? Cisco's network infrastructure hardware uses application-specific integrated circuits, or ASICs. Like human cells, they are designed to carry out one specific task. These specialised processors cut signal delays to less than 5 ms, the time it takes a neurone to fire.



MYELINATED NEURONES

The nervous system carries electrical signals (impulses). Once a receptor (in a sense organ such as your eye or skin) detects a change (stimulus) in your environment, the information is sent as an electrical signal along sensory neurones to your central nervous system (CNS). The brain and the spinal cord make up the CNS. Motor neurones carry signals away from your CNS to effector organs, such as your leg muscles.

Unmyelinated neurones transmit signals as slowly as 1 m/s. Myelin insulates the neurones, enabling the electrical signal to jump along the axon. Myelin increases the conduction speed in neurones to 120 m/s.



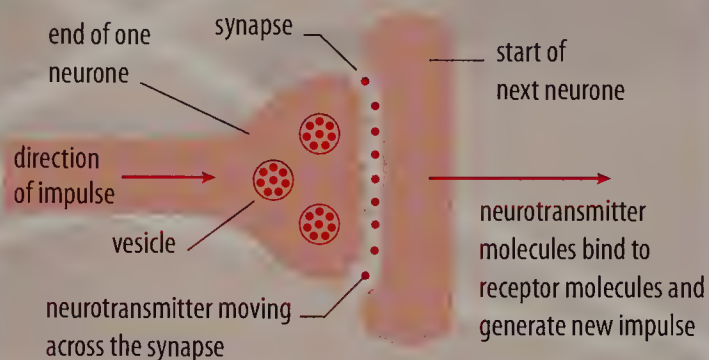
- 1 What sense organ does a sprinter use to detect the sound of the starting gun?
- 2 Draw and label the pathway of the nerve impulse in a sprinter, from the sense organ to the effector organ, when the starting gun is fired.
- 3 Approximately what distance does a nerve impulse travel from the sprinter's brain to their leg muscles?
- 4 How long could this nerve impulse take to travel from the brain to the leg muscles in
 - a an unmyelinated neurone
 - b a myelinated neurone?
- 5 The best athletes will aim to leave the starting blocks 0.11 s after the starting gun is fired. Are the neurones from the brain to the leg muscles myelinated or unmyelinated?

Getting out of the starting blocks more quickly may give a sprinter a split second advantage.



SYNAPSES

Neurones do not pass electrical impulses directly to each other. When a nerve impulse passes from one neurone to the next, it has to cross a tiny gap. These gaps are called synapses. Look at the diagram to see what happens.



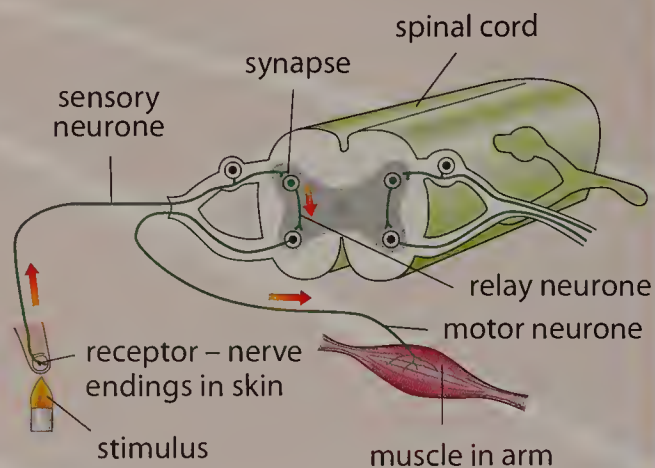
- 1 Describe how a nerve impulse or signal is passed from one neurone to another across a synapse.
- 2 Why can an impulse only pass in one direction along a nerve?
- 3 Some drugs (stimulants) decrease the time it takes for the signals to cross the synapses. Why do you think these drugs are banned in competitive sport?



REFLEX ARCS

The diagram shows how a reflex arc controls a reflex action. The coordinator for a reflex arc is a relay neurone, either in the spinal cord or in the unconscious areas of the brain.

- 1 Define the role of each of the three types of neurone found in a reflex arc.
- 2 Explain why the response time for a reflex arc is quicker than for an impulse from a sense organ to an effector organ that travels via your brain.
- 3 Give an example of how a reflex arc can protect you from injury.
- 4 A very loud sound can startle you and make you 'jump'. When the starting gun is fired at the beginning of the 100 m, does the electrical signal which causes the athlete's response pass along a reflex arc? Explain your answer.





PARALYMPIC ARCHERY

MOTION AND FORCES

NETWORK INFRASTRUCTURE

DID YOU KNOW? Fibre-optic cables running below the River Thames help link the Royal Artillery Barracks to Cisco's London 2012 network infrastructure. Laser-light signals travel through fibre-optic cables at speeds of 182 000 km/s, over 2 million times faster than an arrow in flight.

PARALYMPIC HEROES

Paralympic Archer John Cavanagh won medals at Athens 2004 and Beijing 2008.



FORCE AND ACCELERATION

The force needed to accelerate an object can be calculated using this equation:

$$\text{force (N)} = \text{mass (kg)} \times \text{acceleration (m/s}^2\text{)}$$

An arrow is released with a force of 550 N. The mass of the arrow is 200 g.

- 1 What is the mass of the arrow in kilograms?
- 2 Use the equation above to work out the acceleration of the arrow.
- 3 Another arrow is released with the same force. The mass of this arrow is 300 g. What is the acceleration of this arrow?
- 4 What force would be required for the 300 g arrow to have an acceleration of 2500 m/s²?

The London 2012 Paralympic Archery competition will be held at the Royal Artillery Barracks.



VELOCITY

Velocity is a vector quantity. It is the speed in a given direction. The change in velocity when an archer releases an arrow is called acceleration.

Acceleration is calculated using this equation:

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{final velocity (m/s)} - \text{initial velocity (m/s)}}{\text{time taken (s)}}$$

An archer shoots an arrow. It is in contact with the bow string for 0.02 s, accelerating at 2600 m/s².

- 1 What is the initial velocity of the arrow before it is released?
- 2 What is the final velocity after the arrow is released?
- 3 When the arrow hits the target, it accelerates at -4000 m/s². How long does it take for the arrow to stop moving?



FORCE, ACCELERATION AND VELOCITY

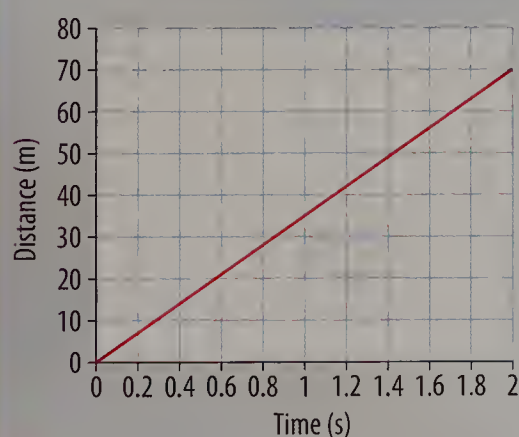
You can combine the equations you know to answer questions involving force, acceleration and velocity.

An object's speed can be calculated from the gradient of a distance-time graph.

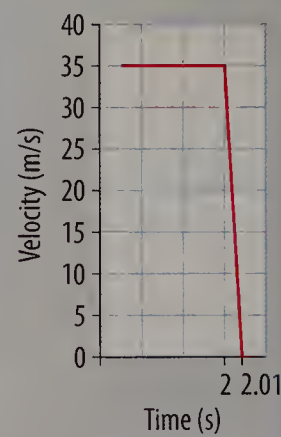
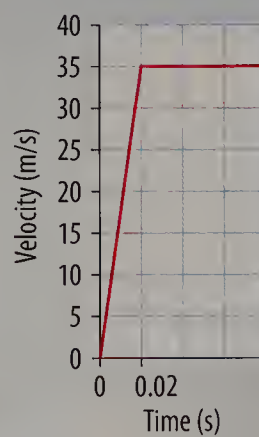
The acceleration of an object and its distance travelled can be calculated from a velocity-time graph.

An archer fired an arrow. Tracking sensors recorded data for the graphs below.

Distance-time graph for the arrow



Velocity-time graphs for the arrow



- 1 What is the distance travelled by the arrow to the target?
- 2 Calculate the average velocity of the arrow during flight.
- 3 What is the acceleration of the arrow as it leaves the bow?
- 4 What is the acceleration of the arrow as it hits the target?
- 5 The arrow has a mass of 150 g.
 - a Calculate the force used to accelerate the arrow from the bow.
 - b Calculate the force used to stop the arrow in the target.

Spanish Paralympic Archer Antonio Rebollo ignited both the Olympic and Paralympic flames at Barcelona 1992 using a flaming arrow.





WATER POLO

HEATING AND INSULATING BUILDINGS

NETWORK INFRASTRUCTURE

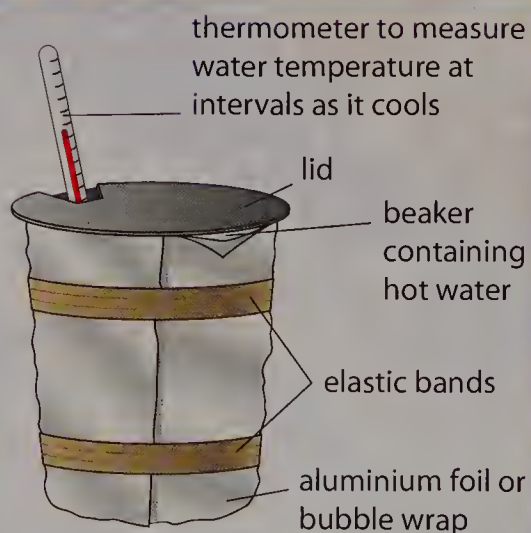
DID YOU KNOW? The supervisor engines in Cisco's core network switches contain 13 heat sinks. Heat sinks are used to cool computer processors. They increase the surface area of the processors, allowing thermal energy to be transferred more efficiently.

The Water Polo Arena is wrapped in recyclable silver-coloured PVC. Its walls use a single layer and its sloping roof is a double skin inflated into cushions.



MINIMISING HEAT LOSS

You can calculate a U-value by measuring how much energy is transferred across a surface. The lower the U-value, the less energy is transferred. To compare the heat loss from three different surfaces, you can measure how quickly beakers of hot water cool. Wrap one beaker with aluminium foil, one beaker with bubble wrap and leave a third beaker unwrapped. Fill the beakers with hot water and cover their tops. Measure the temperature change in each beaker over 15 minutes.



- 1 Make a prediction about which material will act as the best insulator. Use your scientific knowledge to explain your prediction.
- 2 Draw a table to record your results.
- 3 Why should you include an unwrapped beaker in your experiment?

The Water Polo Arena is a temporary venue, and will be dismantled after the 2012 Games to be re-used elsewhere.

HINT

If you carried out the Bronze experiment you can use your own results to answer these questions.



RESULTS

Heather carried out the Bronze experiment. Here are her results.

Insulating material	Temperature (°C)			
	Initial	After 5 min	After 10 min	After 15 min
None	80	72	65	58
Aluminium foil	80	75	71	67
Bubble wrap	80	77	75	73

- 1 Draw a graph to represent Heather's results. Label the horizontal axis 'Time (s)' and the vertical axis 'Temperature (°C)'.
- 2 Work out the change in temperature every 5 minutes for each of the three beakers. Record your answers in a table like this one.

Insulating material	Temperature change (°C)			
	0 to 5 min	5 to 10 min	10 to 15 min	Total temp. change
None	-8 °C			
Aluminium foil				
Bubble wrap				

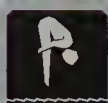
- 3 Which material was the best insulator? Explain your answer using your scientific knowledge.



EVALUATION

Use your own or Heather's experimental results to answer the following questions.

- 1 Explain the difference in the heat loss over each of the time periods for the bubble wrap.
- 2 Use your knowledge of convection, conduction and radiation to explain how
 - a bubble wrap reduces heat loss
 - b aluminium foil reduces heat loss.
- 3 How could you reduce the heat loss from the insulated beakers even more?
- 4 Use the results of this investigation to explain why the designers of the Water Polo Arena covered it with inflatable silver-coloured PVC.



The Aquatics Centre has temporary seating for 17 500 people. This will be reduced to 2500 permanent seats after the 2012 Games.

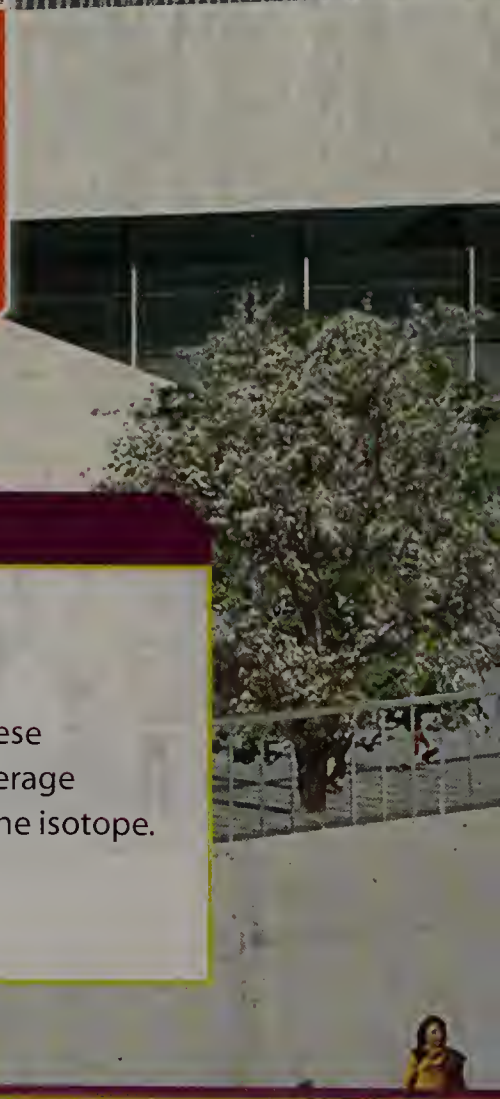
DIVING

CARBON DATING

NETWORK INFRASTRUCTURE

DID YOU KNOW? The power of a wireless signal decreases exponentially as you move away from an access point. Cisco engineers can use equations similar to those used in carbon dating to work out the power at a given distance.

Four skeletons were uncovered during the excavation for the Aquatics Centre. They are thought to be about 3000 years old. Carbon-12 and carbon-14 are two isotopes of carbon. Carbon-12 is the most common because it is stable. Carbon-14 is unstable. It slowly decays to nitrogen. Carbon in the atmosphere combines with oxygen to form carbon dioxide. During photosynthesis, plants convert carbon dioxide to carbon compounds in their tissues. Some of these carbon compounds will contain carbon-14. Animals and people eat plants and absorb the carbon-14. The ratio of carbon-12 to carbon-14 in the air and in all living things is roughly constant. But when an organism dies, it stops taking in carbon. The amount of carbon-12 in the dead organism stays constant but the amount of carbon-14 decreases over time. By comparing the ratio of carbon-12 to carbon-14 in a sample from a human skeleton to the ratio in living organisms, it is possible to work out how long ago the person died.



CARBON DATING

- 1 Copy and complete the sentences below using the following words.

half-life radiation stable time unstable

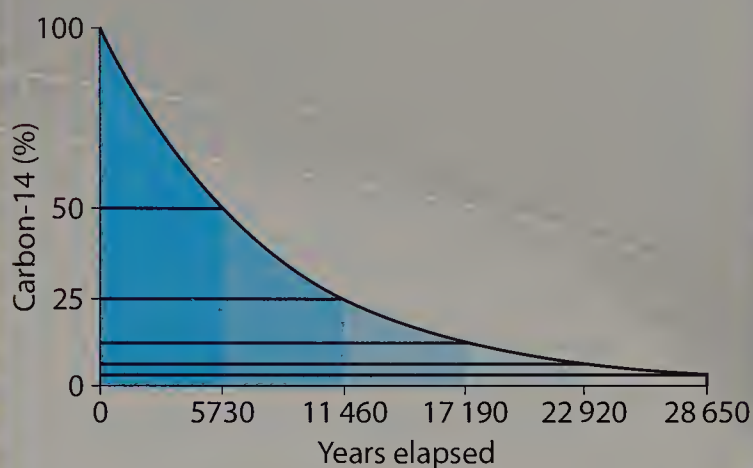
A radioactive isotope contains atoms that have _____ nuclei. Over time, these nuclei decay to form _____ nuclei, releasing _____ as they decay. The average _____ taken for half the unstable nuclei to decay is called the _____ of the isotope.

- 2 What is an isotope?
3 Which isotope of carbon is used for carbon dating?



HALF-LIFE

The graph shows how the percentage of carbon-14 in a living organism decays after it dies.



- 1 What is the half-life of carbon-14?
- 2 How many half-lives of carbon-14 are there in 17 190 years?
- 3 If a sample started with 200 carbon-14 atoms, how many would be left after 17 190 years?
- 4 Approximately how many half-lives of carbon-14 are there in 3000 years?
- 5 Estimate the percentage of carbon-14 present in the bones of a skeleton after 3000 years.

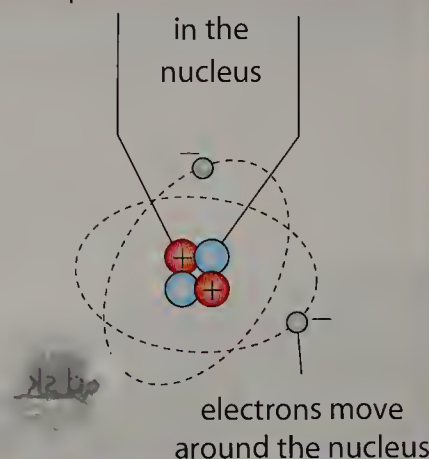


BETA DECAY

The structure of a helium atom is shown here.

- 1 How many protons, neutrons and electrons are there in a carbon-12 atom?
- 2 Draw an atom of carbon-14, showing the protons, neutrons and electrons.
- 3 How many protons, neutrons and electrons are there in a nitrogen-14 atom?
- 4 Draw a diagram to show how carbon-14 decays to nitrogen-14.
- 5 What is beta decay?

protons and neutrons
in the
nucleus



The surface of the diving pool has bubbles or small ripples so that divers can identify the surface of the water during a dive.



The Velodrome makes optimal use of natural light and natural ventilation.

CYCLING

THERMOREGULATION

NETWORK INFRASTRUCTURE

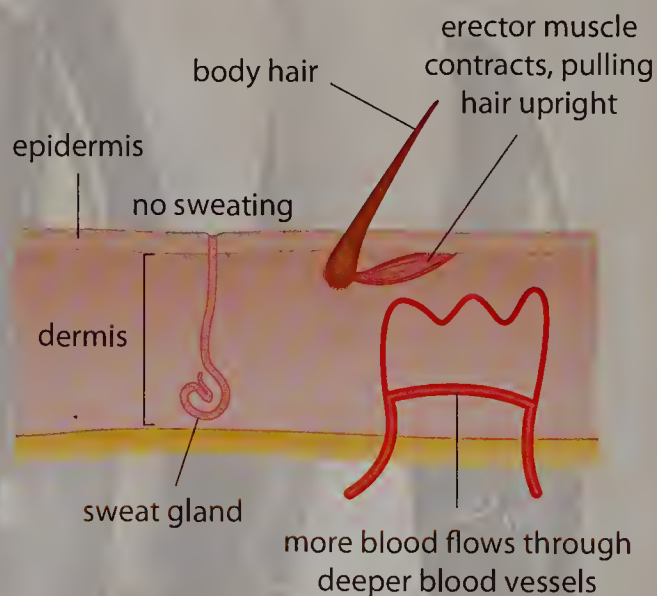
DID YOU KNOW? Temperature regulation is as important for computer processors as it is for Olympic and Paralympic cyclists. Cooling fans on the routers and switches in Cisco's London 2012 network infrastructure adjust their speed depending on the processor temperature.



STAYING WARM

It is vital that your core body temperature is kept around 37°C . Enzymes that control chemical reactions in the cells of your core organs (such as the brain, heart and liver) work best at this temperature. At a few degrees above or below normal body temperature, these chemical reactions will slow down or stop, ultimately leading to death.

In cold temperatures, body hair stands upright in an attempt to trap more air near the skin and so insulate it. Blood flow is reduced near the surface of the skin by narrowing blood vessels (**vasoconstriction**), so reducing the rate of heat transfer from the warm blood to the cool air. Muscles begin to expand and contract rapidly (shivering) in an attempt to generate heat energy by respiration.



- 1 Why is it important to keep the core body temperature around 37°C ?
- 2 Explain why exposed skin may look pale in cold weather.
- 3 Describe three responses of the body if its core temperature falls below 37°C .

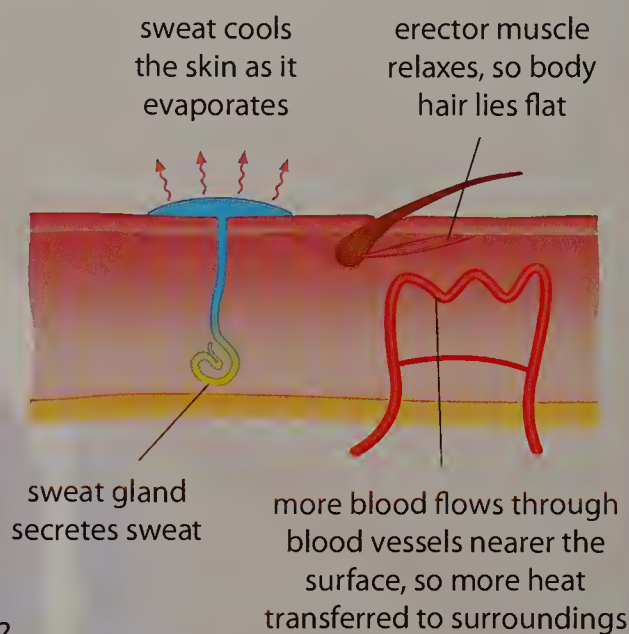
The air temperature on the track in the Velodrome will be kept at up to 28°C during competitions. Increasing the temperature reduces the air density, resulting in less air resistance for the cyclists.



COOLING DOWN

Standing in the sun or exercising for a long period will cause your body temperature to rise. As your body temperature rises above 37 °C you will start to sweat. Blood vessels near the surface of the skin get wider (**vasodilation**), increasing blood flow and so increasing the rate of heat transfer to the air.

- 1 Run as hard as you can on the spot for 2 minutes. Ask a friend to feel your forehead.
 - a Describe how your skin feels after running.
 - b Describe how your skin looks after running.
 - c Describe any other changes to how you feel.
- 2 Why might your skin turn red during and after exercise?
- 3 Rub a drop of water or ethanol onto your skin and blow on it. Why does it feel cold?



HINT

Use your knowledge of energy and states of matter to help explain your answer.



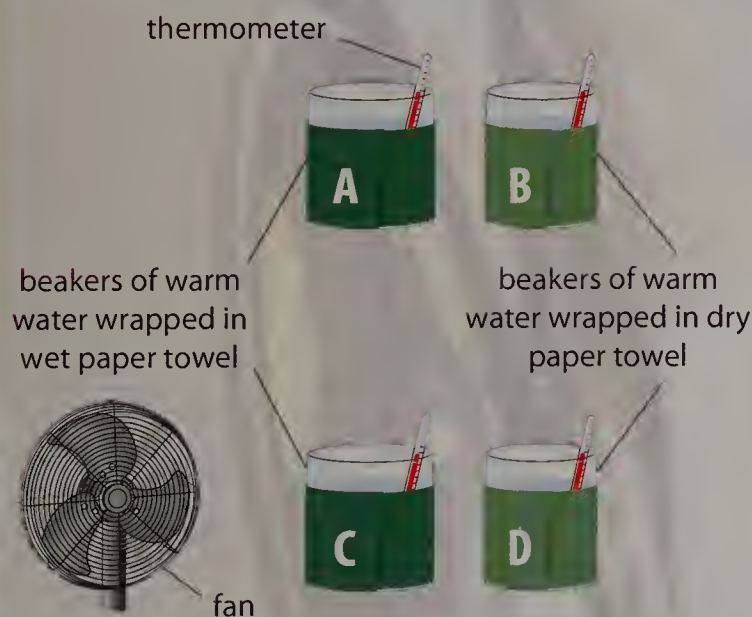
ON THE WEBSITE

Watch videos showing the building of the Velodrome and the legacy VeloPark.



INSIDE THE VELODROME

Amanda carried out this investigation to explain why the cyclists at London 2012 will not get too hot.



- 1 In the diagram, what part of the body does the paper towel represent?

Amanda's results

Time	0 min	5 min	10 min	15 min
Beaker A	60 °C	47 °C	41 °C	35 °C
Beaker B	60 °C	52 °C	47 °C	43 °C
Beaker C	60 °C	43 °C	33 °C	25 °C
Beaker D	60 °C	50 °C	45 °C	40 °C

- 2 Using Amanda's results, list the beakers in the order they cooled. Put the one that cooled fastest first.
- 3 Use your understanding of particles to explain
 - a your answer to question 2
 - b why less air resistance is beneficial for competing cyclists.
- 4 Use the results from Amanda's investigation to explain how cyclists at London 2012 will keep cool while racing in the Velodrome.



Olympic Gold Medallist Paul Goodison sailing his Laser dinghy at Weymouth, June 2011.

SAILING

POLYMERS

NETWORK INFRASTRUCTURE

DID YOU KNOW? The hardware in Cisco's network infrastructure can synchronise its timing based on the nanosecond-accurate clocks in Global Positioning Satellites. Sailors use the same technology to navigate at sea.



BOAT BUILDING

The design specifications for the boats in Olympic and Paralympic sailing are very precise. This ensures that no athlete has an unfair technological advantage. Most parts of the boats are made of synthetic materials, such as polymers. The table below identifies the properties and uses of some common polymers.

Polymer name [common name]	Properties	Uses
Poly(ethene) [polythene]	Flexible, easily stretched, waterproof	Plastic bags, cling film
Poly(propene) [polypropylene]	Flexible, strong, waterproof	Carpets, water pipes, fibres
Poly(chloroethene) [PVC]	Hard, tough, waterproof	Window frames, gutters, pipes
Poly(tetrafluoroethene) [Teflon® or PTFE]	Tough, slippery, good insulator, waterproof	Non-stick coating for saucepans, clothing

- The ropes for the boats are made from a polymer.
 - Which polymer would be best suited for ropes?
 - What are the properties of this polymer that make it good for ropes?
- Cam-cleats hold the rope from slipping but also allow the rope to be adjusted easily.
 - Which polymer would be best for making cam-cleats?
 - What are the properties of this polymer that make it suitable for cam-cleats?
- It is illegal to coat a boat's hull with a polymer such as PTFE.
 - What advantage would PTFE give to an Olympic or Paralympic sailing boat?
 - PTFE is permitted on clothing. What properties of PTFE make it suitable for aquatic clothing, and why?

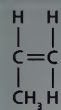




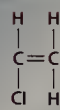
POLYMER BUILDING

Polymers are made by joining many small molecules called monomers together. When molecules such as ethene join together, the double bond between the carbon atoms is broken and is replaced by a single bond. The number of monomers in a polymer varies. There can be several thousand monomers in a single polymer molecule.

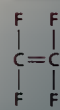
HINT



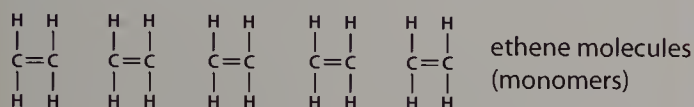
propene



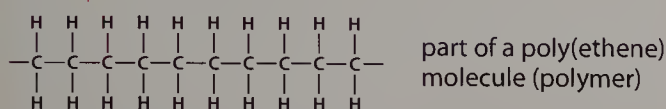
chloroethene



tetrafluoroethene



↓ polymerisation

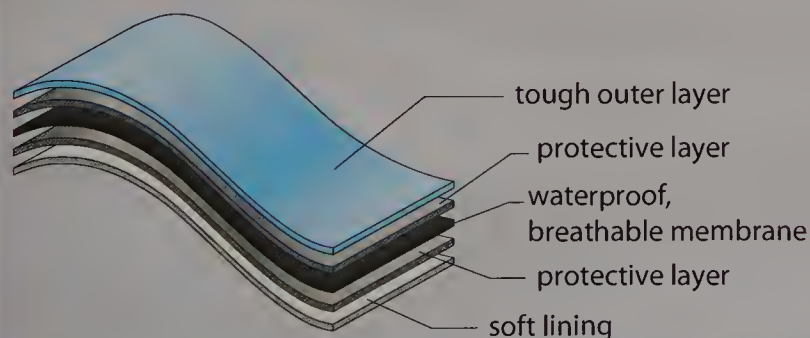


- 1 Draw diagrams to show how two monomers join to form
 - a poly(propene)
 - b poly(chloroethene)
 - c poly(tetrafluoroethene).



TESTING POLYMERS

The right clothing is important to ensure sailing competitors keep warm and dry. It needs to protect them from both wind and water, but also allow sweat to evaporate. Specialised fabrics have a waterproof, breathable membrane that includes layers of nylon and PTFE. The PTFE is very thin and contains approximately 14 million holes or 'pores' per square millimetre. The tiny pores allow water vapour, but not liquid, to pass through the membrane.



- 1 Explain what is meant by a 'waterproof, breathable membrane'.
- 2
 - a Explain the purpose of the PTFE layer in the membrane.
 - b Why do you think nylon is added to the membrane?
- 3 You can test the strength of a material by stretching it until it breaks.
 - a Design an experiment to compare the strength of one of these specialised fabrics with the strength of other materials. Explain what apparatus you would need, how you would carry out your experiment and how you would record your results.
 - b What factors would you need to keep the same when testing different materials?





DECATHLON

METALS AND THEIR USES

NETWORK INFRASTRUCTURE

DID YOU KNOW? Cisco's engineers will install more than 300 wireless access points in the Olympic Stadium, making sure that spectators can catch up on the latest results and videos on their laptops, phones and tablets. Silver is widely used in electronic devices because it conducts electricity very well.



The top ring of the Olympic Stadium was built using surplus gas pipes. Steel and concrete use was reduced by designing the lower section of the stadium to sit within a bowl in the ground. The external structure of the stadium is covered by a temporary 'wrap' which uses less material than traditional cladding.



ON THE WEBSITE

Watch a time-lapse video showing construction of the stadium.



PROPERTIES OF IRON AND STEEL

The following properties are typical of metals, though not all metals have all of these properties:

good thermal conductor
good electrical conductor
high melting point
strong
ductile
malleable
shiny

- 1 Explain the meaning of the following words.
a strong b ductile c malleable
- 2 The framework of the Olympic Stadium is constructed from steel. What are the properties of steel that make it suitable for the framework?
- 3 The London 2012 Olympic Torch will be made of an aluminium alloy. Which properties of metals make aluminium a suitable material for the Olympic Torch?

Steel is heavy, expensive and energy intensive to produce. The London 2012 Olympic Stadium uses 75% less steel than other similar stadiums.

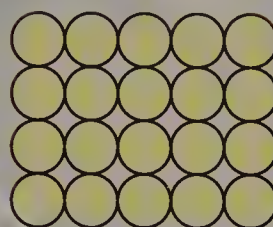


ALLOYS OF IRON

Pure iron is a soft metal and is easily shaped. The atoms in pure iron are arranged in layers. These layers of atoms can easily slide over one another.

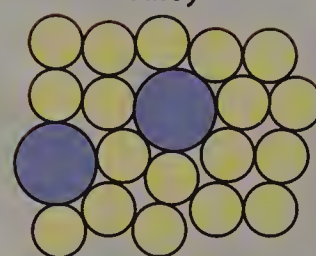
An alloy is a metal with one or more other elements added to change the metal's properties. Steels are alloys based on iron, usually with carbon added to stop the layers sliding and make it stronger and harder.

Pure iron metal



iron atom

Alloy



atom of another element

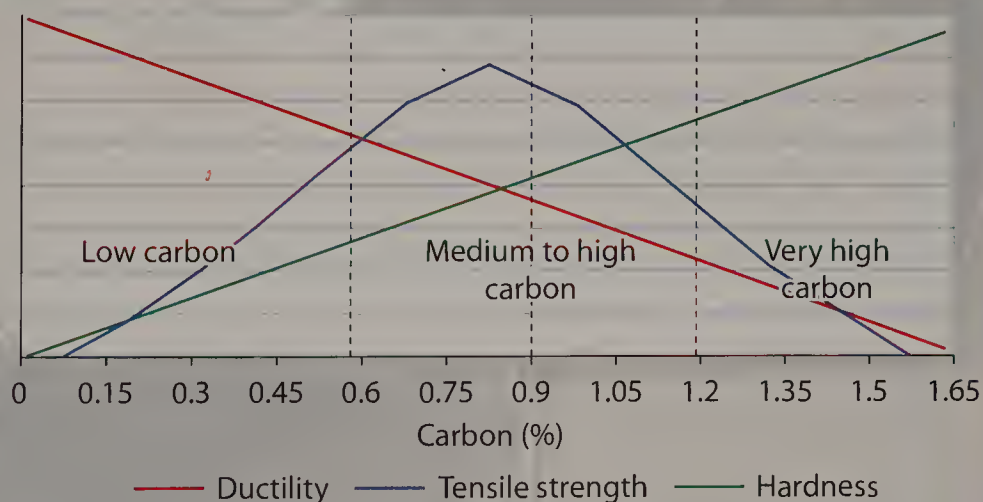
- 1 Why is it easy to change the shape of pure iron?
- 2 Why is steel harder than pure iron?
- 3 Carbon atoms are smaller than iron atoms. Draw diagrams to show
 - a steel with a few carbon atoms (low-carbon steel)
 - b steel with a lot of carbon atoms (high-carbon steel).
- 4 Which steel would be harder, low- or high-carbon? Explain your answer.



CARBON STEEL

The graph shows how the properties of steel change with the percentage of carbon added.

- 1 What percentage of carbon gives steel the strongest tensile strength?
- 2 Describe how the properties of steel change as the percentage of carbon is increased.
- 3 Ten steel cables form a ring for the central opening of the Olympic Stadium. Which type of steel would be best suited to this role? Explain your choice.
- 4 The steel rakers on the Olympic Stadium need to be strong enough to support the seating for 55 000 spectators, but flexible enough to support the structure as it expands and contracts in the heat. Which type of steel would be best suited to this role? Explain your choice.





ROWING

DIABETES

After being diagnosed with Type 1 diabetes, Sir Steven Redgrave went on to win his fifth Olympic Gold Medal in his fifth consecutive Olympic Games.

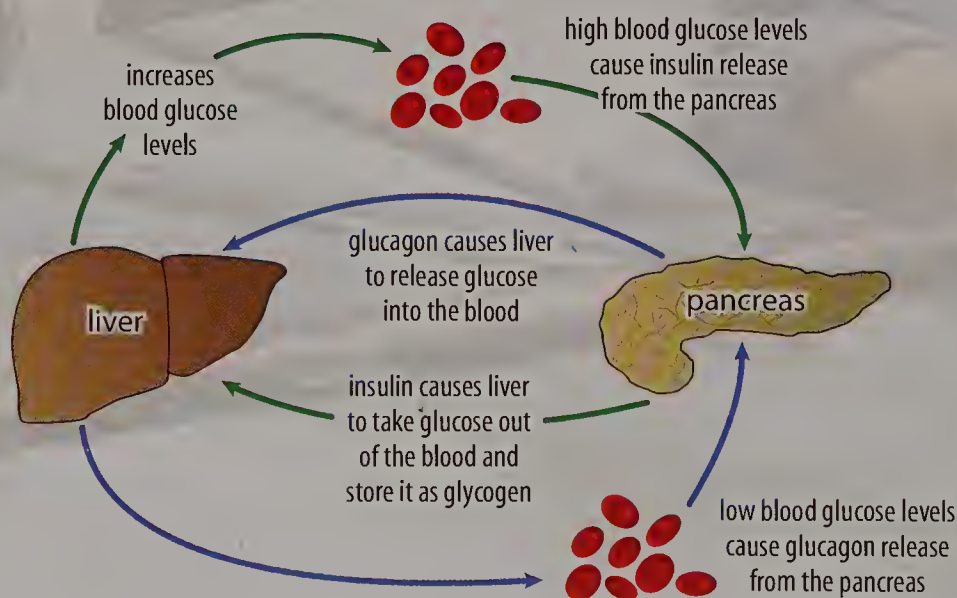
NETWORK INFRASTRUCTURE

DID YOU KNOW? Cisco's high-speed network infrastructure can get information from the Rowing venue at Eton Dorney back to the Olympic Park in less than 0.005 seconds. Signals travel through copper cables as electrical impulses. These signals are similar to the nerve impulses which tell a rower's muscles to contract or relax.



BLOOD GLUCOSE CONCENTRATION

Cells need a constant supply of glucose for respiration. This is mostly supplied from carbohydrates that are broken down by the digestive system to form glucose. Some glucose is converted to glycogen and stored in the liver. During exercise, glycogen in the liver can be rapidly broken down to glucose for respiration within muscle cells. The pancreas produces the hormones insulin and glucagon to keep the concentration of glucose in the blood within a limited range.



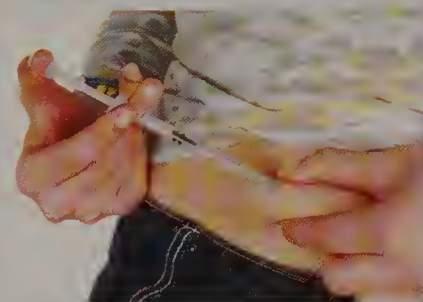
- 1 What are carbohydrates used for in the body?
- 2 How does insulin reduce blood glucose levels?
- 3 How do the pancreas and liver respond to increased blood glucose levels?

The water at Eton Dorney comes from underground streams. The excellent water quality is achieved by restricting the use of fertilisers on surrounding farmland and discouraging algal growth using barley bales at the end of the lake.



TYPE 1 DIABETES

Diabetes is a condition where the amount of glucose in your blood is not controlled properly. A very high glucose concentration can result in the short-term effects of fatigue or even coma. Repeated episodes of glucose levels which are too high or too low can lead to damage to nerves and to organs such as the heart and eyes.



Type 1 diabetes accounts for 5% to 15% of all diabetes cases. People who suffer from Type 1 diabetes need to inject insulin into their body to regulate their blood glucose levels because their pancreas does not produce any insulin.

- ① Why does an increase in the amount of food that a diabetic person eats also increase the amount of insulin they need?
- ② Rowers train for up to 8 hours per day in preparation for an event.
 - a Explain why a diabetic rower would need to be more careful in controlling his diet than a non-diabetic rower.
 - b Explain why he would eat lots of carbohydrates in the evening.
- ③ Explain how too much insulin could be dangerous.

HINT

Think about what would happen to the glycogen levels in his muscles.

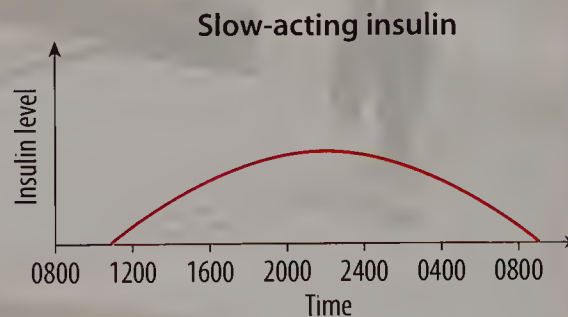
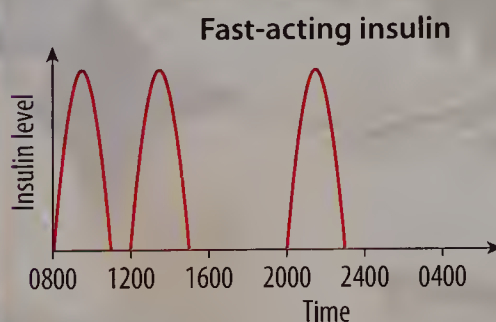
HINT

Think about how the heart and brain would function without glucose.



INSULIN

Insulin can be classed as fast-acting insulin or slow-acting insulin. A diabetic rower took a combination of both fast- and slow-acting insulin to regulate his blood glucose levels during training.



- ① What type of eating habits would be best suited to someone taking slow-acting insulin?
- ② Sketch a graph showing the insulin levels of someone taking a mixture of fast- and slow-acting insulin.
- ③ What are the benefits of taking a mixture of both types of insulin?
- ④ Explain why a diabetic rower would take very small amounts of fast-acting insulin during training and large amounts of mixed insulin after training.



The Media Centre will operate 24 hours a day, every day of the London 2012 Games.

MEDIA CENTRE

COMMUNICATION

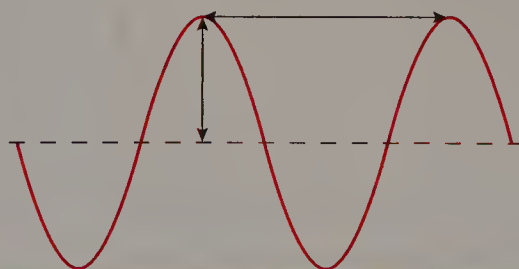
NETWORK INFRASTRUCTURE

DID YOU KNOW? Wi-fi signals are electromagnetic waves. Cisco's wireless network access points can send and receive signals with frequencies of 2.4 GHz or 5 GHz. Higher frequency signals have a shorter wavelength and can transmit more information.



TRANSVERSE WAVES

Mobile phone signals, television and radio broadcasts and computer data can all be transmitted as electromagnetic waves. Electromagnetic waves travel as transverse waves. The **amplitude** of a wave is the maximum distance that a point moves away from its position of rest. The **wavelength**, measured in metres, is the distance between two crests or two troughs of a wave. The **frequency** of a wave is the number of waves passing a point each second. Frequency is measured in hertz (Hz).



- 1 Copy the diagram of a transverse wave and label each of these features:
wavelength, amplitude, crest, trough
- 2 Use a ruler to measure the wavelength and amplitude of the wave.
- 3 Copy and complete these sentences.
 - a The distance between two successive peaks of a wave is called the _____.
 - b The _____ is the number of waves produced by a source each second.
 - c The distance from the resting position of a wave to a trough is called the _____ of the wave.



RADIO WAVES AND MICROWAVES

Wave speed is a measurement of how fast the energy in a wave travels, and can be calculated using this equation:

$$\text{wave speed (m/s)} = \text{frequency (Hz)} \times \text{wavelength (m)}$$

Waveband	Frequency range	Waveband	Frequency range
Microwaves	Greater than 3000 MHz	HF (high frequency)	3–30 MHz
UHF (ultra-high frequency)	300–3000 MHz	MW (medium wave)	300 kHz–3 MHz
VHF (very high frequency)	30–300 MHz	LW (long wave)	Less than 300 kHz

$$1 \text{ MHz} = 1\,000\,000 \text{ Hz}$$

Assume that electromagnetic radiation travels at 300 000 000 m/s in air.

- 1 Calculate the range of wavelengths for each waveband in the table travelling at this speed.
- 2 Mobile phones in the United Kingdom use a wavelength of approximately 16 cm. Which waveband does this fall into?
- 3 Radio 5 Live is transmitted at 693 kHz. What is the wavelength at this frequency?

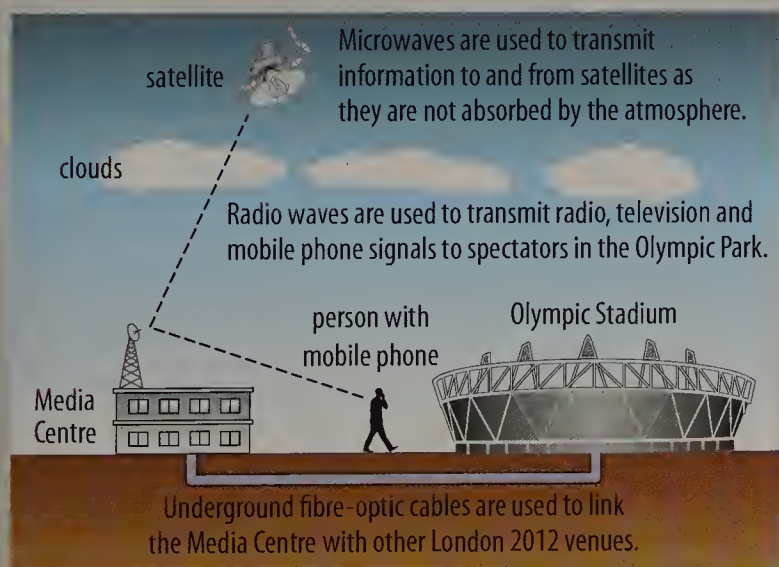
HINT

Make sure you use the right units in your calculations.

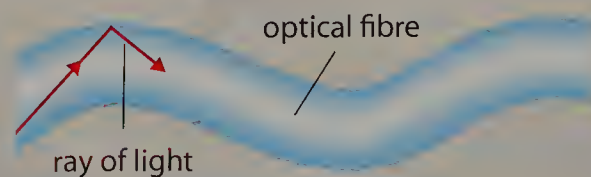


RADIO WAVES, MICROWAVES AND INFRARED

Coverage of the London 2012 Games will be broadcast across the UK and around the world. Much of this information will be sent as electromagnetic waves. The diagram below shows how electromagnetic signals will be used in the Olympic Park.



- 1 What type of electromagnetic wave will be used to send television signals to the United States and Australia? Explain your answer.
- 2 Explain why your mobile phone might not work when you are in a valley or narrow alleyway.
- 3 The diagram below shows the path of a light ray in an optical fibre. Copy the diagram and complete the path of the ray as it travels along the fibre.



- 4 Optical fibres are made of glass or plastic. Use your knowledge of wavelength and absorption to explain why infrared light is usually used to transmit information through optical fibres.

DESIGNING A MAJOR SPORTING EVENT

1 LOCATION

NETWORK INFRASTRUCTURE

DID YOU KNOW? As well as providing the network infrastructure for every London 2012 venue, Cisco has linked up transport hubs, training grounds and ticketing booths. By using existing telephone exchanges and wires, Cisco engineers are able to network venues like the Lee Valley White Water Centre more efficiently.

At London 2012 the canoe slalom event will take place at the newly built Lee Valley White Water Centre. On the next six pages you will learn about some of the challenges of planning this major sporting event.

White Water Centre is the first of new London 2012 venues to be completed



November 2009 and construction is underway...



... and one year later the water is flowing.

The Lee Valley White Water Centre was opened in Spring 2011. It is 30 km north of the Olympic Park, and is part of the Lee Valley Regional Park which stretches 26 miles along the banks of the River Lee. Park visitors can take advantage of cycle and walking trails, a golf course and an athletics centre.

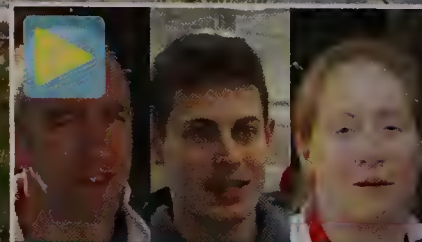
CHALLENGE 2012

PLAN AN EVENT NEAR YOUR SCHOOL

Could you design a major sporting event in your area? The Maths and Science Challenge 2012 gives you an opportunity to do just that.

Choose a sport and a venue, then use your maths and science skills to plan your event. Tackle some of the problems faced by London 2012 organisers and create a video telling us why your event is so great. You could be in with a chance of winning Challenge 2012! So get a team together, find a willing teacher, and get planning.

For more information visit www.mathsandscience2012.co.uk/challenge2012



ON THE WEBSITE

Watch some of Britain's medal hopes welcome you to Challenge 2012.

Up to 60 000 spectators are expected to watch the canoe slalom event at the Lee Valley White Water Centre. Temporary stands will mean they all have a great view.

CHALLENGE 2012

CHOOSING A SPORT

Choosing a popular sport or one where Team GB have a good chance of winning medals will help you ensure a sell-out crowd.

Canoeing becomes fastest growing water sport in UK

With 1.2 million participants in 2010, canoeing has surged in popularity in recent years.

At Beijing 2008, Great Britain's David Florence won a Silver Medal in the canoe slalom. It's a fast and exciting sport, which is one of the reasons why tickets to the canoe slalom sessions at London 2012 were so popular.

In the London 2012 canoe slalom, 82 athletes will compete for four Gold Medals. Competitors must negotiate a course of up to 25 coloured gates. Touching a gate means a 2-second penalty. Missing a gate completely results in an unrecoverable 50-second penalty.



David Florence claims Silver at Beijing 2008

Great public transport links help visitors take greener option

The Lee Valley White Water Centre is a 10-minute walk from Waltham Cross train station or a 20-minute walk from Cheshunt train station. During London 2012, spectators with tickets to the canoe slalom will receive a Games Travelcard. This will entitle them to free travel on London public transport on the day of the event, and on National Rail services between London and the White Water Centre.

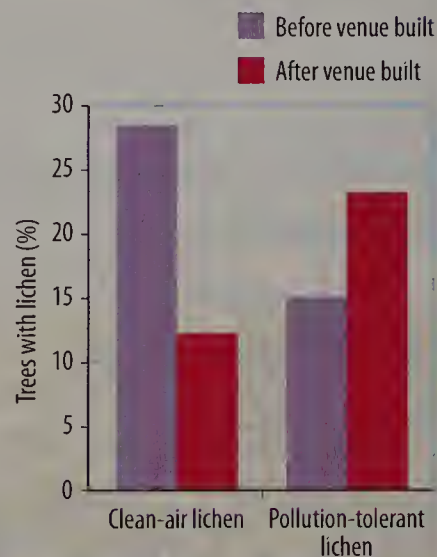
Science Skills

1 Limiting pollution is an important consideration in developing any Olympic Venue. The positioning of the Lee Valley White Water Centre near public transport links helps reduce the air pollution from transport.

- What types of pollution need to be controlled at the White Water Centre?
- How can the London 2012 organisers minimise the impact of pollution at the White Water Centre?
- How could scientists measure the impact of pollution at the White Water Centre?

2 The amount of some forms of lichen on trees can be used to measure changes in air pollution. Daryl measured the lichen on some trees before and after the Lee Valley White Water Centre was built. The graph presents his results.

- Describe how the types of lichen changed after the White Water Centre was built.
- What types of variables should Daryl try to control?
- How could Daryl improve this investigation?



DESIGNING A MAJOR SPORTING EVENT

2 VENUE

NETWORK INFRASTRUCTURE

DID YOU KNOW? The decision to use a permanent or a temporary venue has an impact on the network infrastructure. In temporary venues, Cisco engineers are able to run cables along the floor and under seating. In permanent venues, ducts are used to hide network cables inside walls and underneath flooring.

Could you handle the Olympic Course?

The Lee Valley White Water Centre has two different courses, which are both open to the public. The Olympic Course is 300 m long and drops 5.5 m. The Legacy Loop is a less challenging intermediate course, which is 160 m long with a descent of 1.6 m.

The white water is created using a system of pumps and obstacles. The obstacles can be moved around to change the features of the course.



Both courses feature conveyor belts to carry canoes up to the start.

CHALLENGE 2012

DRAWING A PLAN

A plan of your venue can show its key features.



ON THE WEBSITE

Watch Colin Naish from the Olympic Delivery Authority talk about the canoe slalom course.

Over 150 000 m³ of soil was put in place to form the slopes and landscaping at the Lee Valley White Water Centre.

A swimming pool's worth of water pumped down Olympic Course every 30 seconds

13 000 litres of water pour down the Olympic Course every second. There are five 350 kW pumps on the Olympic Course, although only four are ever in use at a time. Each pump weighs as much as an elephant. With hundreds of people using the courses every day, it's important to make sure the water is clean and safe. Chlorine is added to keep the water free from dangerous bacteria. The amount of chlorine is about 0.1 parts per million. This is similar to the amount of chlorine in treated drinking water.



There are three 150 kW pumps on the Legacy Loop.

White Water Centre to have first-class facilities and a great view

The two-storey facilities building contains a café, changing rooms, offices and spectator viewing areas.

The landscaping of the site includes sloped grassy areas around the course, providing natural vantage points for spectators.

On average 1300 people visit the Lee Valley White Water Centre each day. During the 2012 Games up to 12 000 people a day will come to see the action. Temporary seating will be constructed in order to accommodate the extra spectators.



Science Skills

- 1 Look at the information about the pumps at the White Water Centre.
 - a How much energy is required to power the four pumps on the Olympic Course for one hour? Give your answer in kWh.
 - b If electricity is charged at 6.94p per kWh, how much will it cost to run the Olympic Course from 9.30am to 5pm for the two weeks of the 2012 Games?
- 2 Write down two other forms of energy that could be used to power the pumps at the Lee Valley White Water Centre. Explain the pros and cons for each form of energy.

DESIGNING A MAJOR SPORTING EVENT

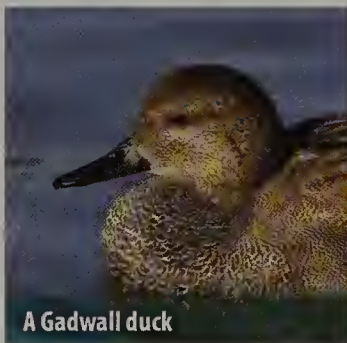
3 LEGACY

NETWORK INFRASTRUCTURE

DID YOU KNOW? Cisco plans to set up 50 new Networking Academies in the London 2012 host boroughs. Through online courses, these programmes will train local people for highly-skilled jobs in ICT.

Birds, bats and biodiversity

Before building the White Water Centre a habitat management plan was created, showing how the impact of the centre on wildlife and the natural environment could be minimised.



A Gadwall duck

- 22 species of nesting bird were recorded in the area. Any removal of trees and plants was carried out before the birds began building their nests at the start of March.
- Bats do not like crossing well-lit areas to find food. During construction, lighting was directed away from the woodland edge and waterways, and 15 bat feeding boxes were installed.
- 1% of the world's population of the Gadwall duck and 1.5% of the world's population of the Shoveler duck spend their winter in the Lee Valley Regional Park. Buffer zones were created between the site and animal habitats in order to protect these water birds.

CHALLENGE 2012



DESIGNING FOR SUSTAINABILITY

Will your event be environmentally friendly? Using materials from sustainable sources for construction, and encouraging spectators and athletes to recycle are just two ways to minimise any negative impact on the local area.



As well as canoeing, visitors to the Lee Valley White Water Centre can also experience white water rafting. This means a much wider range of people can make use of the centre after the 2012 Games.

White Water Centre will have something for everyone before and after the 2012 Games

The Lee Valley White Water Centre has been open to the public since Spring 2011. Thousands of people have already enjoyed the centre, and thousands more will continue to use it after the 2012 Games. In 2015 it will host the Canoe Slalom World Championships.

The area surrounding the White Water Centre is one of the most deprived in Hertfordshire. As well as creating 50 new jobs, the presence of a major leisure attraction benefits local businesses. Visitors use shops, restaurants and accommodation. In December 2009, a canoe and kayak shop opened opposite the site of the centre.

The White Water Centre has a full-time Youth and Schools programme, which works with local schools on a range of projects.



Footpaths around the Olympic Course will be open to the public after the 2012 Games.

Students can practise orienteering on the site, learn about leisure and tourism management, or explore the varied wildlife in the area. In June 2011 the centre hosted the White Water Schools Festival, with students from 126 schools rafting on the Olympic Course.

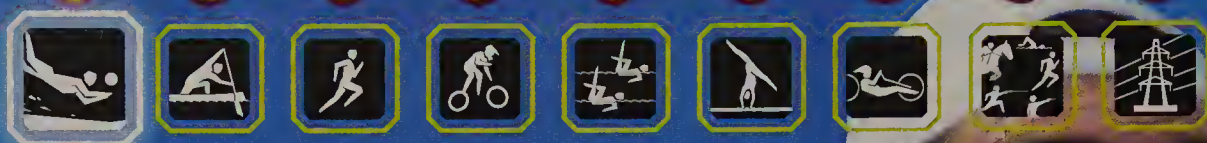
CHALLENGE 2012

TRANSFORMING A COMMUNITY

Hosting a major sporting event can change an area or community dramatically. It's your responsibility to make sure that your event has a positive impact on your local area. Will the venue be used by the public after the event? Will it host other national or international competitions? What are the benefits to the local community? Can you plan activities which will involve students from local schools?

Science Skills

- 1 The Lee Valley White Water Centre is part of the Lee Valley Regional Park which stretches 26 miles along the banks of the river Lee.
 - a What are the different types of habitats found around the Lee Valley White Water Centre?
 - b What types of organisms would you expect to find in each of these habitats?
 - c What impact might the White Water Centre have on these organisms and habitats?
- 2 The wildlife around the Lee Valley White Water Centre is a big attraction for visitors. Describe how you could use sampling to measure and identify the wildlife around the White Water Centre.



3000 tonnes of sand will be brought in to Horse Guards Parade to make a temporary 'beach' for the Olympic Beach Volleyball tournament.

BEACH VOLLEYBALL

STRUCTURE AND BONDING

NETWORK INFRASTRUCTURE

DID YOU KNOW? Electrical signals are carried by moving electrons in a conductor such as a wire. Computer chip manufacturers use ultraviolet light to 'print' electron pathways onto silicon wafers. In the Opteron processors in Cisco's networking hardware these pathways are 45 nanometres wide.



ELECTRONIC CONFIGURATION

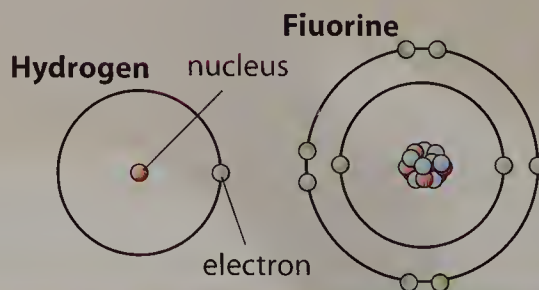
Atoms are the building blocks of everything, from the sand on the beach volleyball courts to the water in the Aquatics Centre. Atoms consist of a nucleus containing protons and neutrons, surrounded by electrons. The arrangement of electrons in an atom is called the electronic configuration.

Electrons are arranged in shells. Each shell has a maximum number of electrons it can hold. The first shell can hold 2 electrons; the second and third shells can each hold 8 electrons. When an electron shell is filled, further electrons are held in a new shell. A full outer shell is generally more stable than a partially filled outer shell.

Hydrogen has 1 electron. Its outer shell can contain a maximum of 2 electrons.

Fluorine has 9 electrons, 2 in the first shell and 7 in the outer shell. Its outer shell can contain up to 8 electrons so it would need one more electron to fill its outer shell.

- 1 Draw diagrams to show the electronic configuration of each of these atoms.
a oxygen b carbon c nitrogen d chlorine
- 2 For each atom in question 1, state how many more electrons are needed to fill the outer shell.
- 3 An atom has 16 electrons.
a What is the atom's electronic configuration?
b How many electrons are needed to fill the outer shell?
c What is the name of this atom?



HINT

Use the periodic table to find out the number of electrons for each atom.



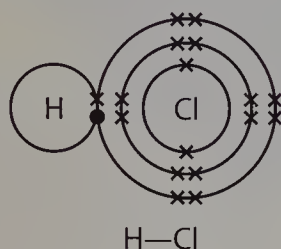
SIMPLE COVALENT MOLECULES

One way of filling the outer shell is by sharing electrons between atoms to form covalent bonds. These bonds are very strong. It takes a lot of energy to break them. You can use dot and cross diagrams to show how the electrons are shared. You can also use a single line to represent a bond.

Hydrogen chloride molecule

By sharing electrons, the outer shell of hydrogen has 2 electrons and the outer shell of chlorine has 8 electrons.

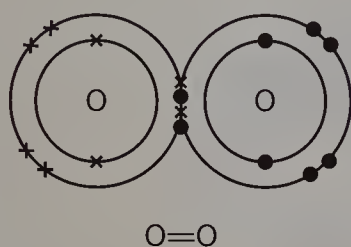
The simplified structure shows the covalent bond as a single line.



Oxygen molecule

Each oxygen atom shares 2 electrons with the other oxygen atom, giving a full outer shell and forming a double bond.

In the simplified structure the double bond is represented by two lines.



- 1 How many electrons are in the outer shell of each individual oxygen atom?
- 2 Draw a dot and cross diagram for each of the following molecules.

a N₂ b CO₂ c H₂O

- 3 Methane (CH₄) is found in the atmosphere – some of it is produced by the horses on Horse Guards Parade! Draw a dot and cross diagram showing the structure of methane.

- 4 Draw a simplified structure for each of the following molecules.

a N₂ b CO₂ c H₂O d CH₄

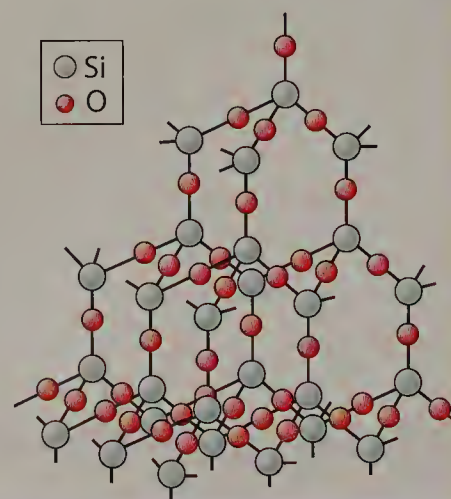
- 5 Draw the electronic configuration of argon and use this to explain why it does not form covalent bonds.



GIANT MOLECULAR STRUCTURES

The sand used for the beach volleyball courts needs to meet strict standards. Sand consists mostly of silicon dioxide (SiO₂). Atoms such as carbon and silicon form bonds with more than one other atom. Silicon dioxide forms giant molecular covalent structures which we see as sand crystals.

- 1 In the diagram of silicon dioxide, how many other atoms
 - a is each silicon atom joined to
 - b is each oxygen atom joined to?
- 2 Explain why silicon dioxide can form a giant molecular structure.
- 3 Explain why sand is one of the hardest materials found on Earth.





Eton Dorney will be used for the Rowing and Canoe Sprint events at London 2012.

CANOE SPRINT

DIET AND EXERCISE

NETWORK INFRASTRUCTURE

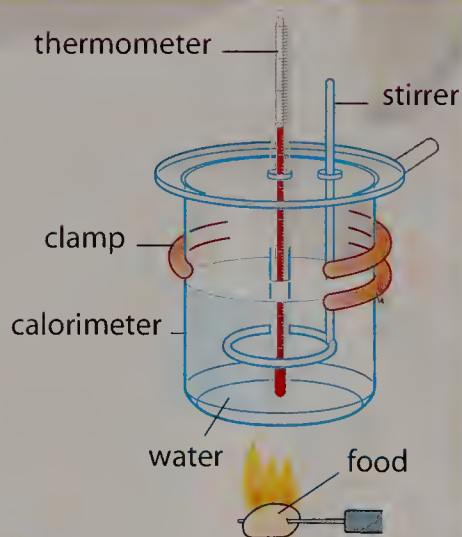
DID YOU KNOW? Energy efficiency is just as important in a network as it is for an Olympic or Paralympic athlete. Cisco engineers monitor the power being used by each network infrastructure component. Cisco Energy Wise technology can shut off non-critical systems if there is a need to reduce energy usage.



HOW MUCH ENERGY?

We get the energy we need for all the life processes in our bodies from the food we eat and drink. Olympic and Paralympic athletes need to plan their diets carefully to make sure they have enough energy for training and competitions.

Ali is carrying out an experiment to compare the energy in different foods. He can do this by burning each food to release its energy and heat a beaker of water, as shown in the diagram.



Food (10 g)	Temperature of water	
	Before burning (°C)	After burning (°C)
Crisp	25	33
Bread	27	45
Pasta	23	26

HINT

You can use your own results or the results shown in the table to answer these questions.

- Which type of food contains the most energy per 10 g?
- Ali can use this investigation to compare foods, but it won't tell him the total energy stored in the food. Why is only some of the energy from the food absorbed by the water?

OLYMPIC HEROES

As well as being an Olympic Gold Medallist, Tim Brabants is a qualified medical doctor.



ON THE WEBSITE

Watch Tim talk about his training schedule and diet.



METABOLIC RATE

Your body needs energy to carry out the processes that keep you alive such as digestion, breathing, keeping your heart pumping and keeping you warm. Energy is also needed for cells to grow and divide, and for activity, such as running, swimming and talking. The rate at which energy is transferred in the body is called the metabolic rate. Different types of cells need different amounts of energy. For example, muscle cells need more energy than fat cells.

- How could you improve Ali's investigation to make the results more accurate?
- For each pair **a–d** in the table below, state which person would have the higher metabolic rate. Give a reason for your choice.

	Person 1	Person 2
a	Child who exercises a lot	Child who exercises little
b	70-year-old	Teenager
c	10-year-old girl in winter	10-year-old girl in summer
d	Olympic rower	Olympic archer

- Why does an elite athlete have a higher metabolic rate than an obese person?
- What happens to your weight if you consume more energy than your body needs?
- Explain how your metabolic rate could be changed by
 - where you live
 - the activities you do.



ENERGY CONSUMPTION

Carbohydrates and fats in our diet provide most of our energy requirements. The amount of energy an athlete takes in as food must be equal to the amount of energy consumed by exercise.

Andrew's diet during training (approx. 3500 kcal, 630 g carbohydrate, 125 g protein and 60 g fat)

Meal	Food	Drink
Break-fast	2 thick slices of wholegrain toast with jam OR large bowl of cereal; plus 1 tub of yogurt	200 ml fruit juice
Snack	Piece of fruit	500 ml sports drink
Lunch	2 wholemeal rolls with low-fat filling of salmon, chicken or egg and salad	200 ml fruit juice
Snack	1 packet pretzels OR 2 small low-fat muffins OR muesli bar	250 ml flavoured milk OR fruit smoothie
Dinner	Large bowl of pasta with low-fat sauce plus 2 cups vegetables plus 1 bread roll	500 ml water
Snack	1 tub of yogurt OR fruit smoothie	500 ml sports drink

- What is the mass percentage of each food group in Andrew's training diet?
- Which food group forms the main part of Andrew's training diet? Why is this food group important?
- In the week leading up to a race Andrew needs to increase the amount of glycogen (a store of energy) in his cells. How could he change his diet to achieve this?
- What foods do you think Andrew should eat on the morning of his race? Justify your choice.



The London 2012 Marathon will begin and end on The Mall near Buckingham Palace.

MARATHON

RESPIRATION

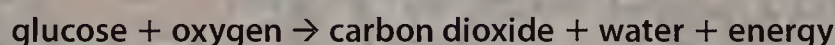
NETWORK INFRASTRUCTURE

DID YOU KNOW? A dress rehearsal of the marathon was just one of the 'test events' carried out before the London 2012 Games. Wheelchair athletes and runners from London athletic clubs were invited to try out the Olympic Games course, giving Cisco's engineers the opportunity to test key technologies.

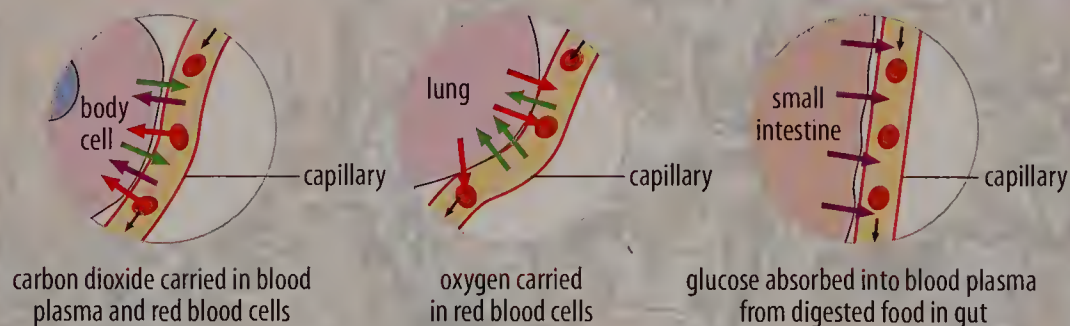


AEROBIC RESPIRATION

In **aerobic respiration**, glucose (from digested food) reacts with oxygen to produce carbon dioxide and water and release energy. Aerobic respiration takes place inside the mitochondria of cells. The process can be summarised as follows:



Glucose is a simple sugar which is provided mostly by the digestion of carbohydrates and fats in foods.



Key:
→ movement of glucose molecules → movement of oxygen molecules
→ movement of carbon dioxide molecules → direction of blood flow

- 1** Using the keywords given, describe fully
 - a how oxygen from the air reaches the mitochondria in cells
 - b how glucose transported from food in the gut reaches the mitochondria in cells
 - c how carbon dioxide produced by respiration in cells is removed from the body.

KEYWORDS

glucose lungs
 aerobic respiration
 energy water
 carbon dioxide
 digestion heart

The London 1908 Marathon started outside Windsor Castle, and finished opposite the Royal Box in the Olympic Stadium in White City. This route set 26 miles and 385 yards (42.195 km) as the standard distance for the marathon.



INVESTIGATING THE EFFECTS OF EXERCISE

All cells need energy to carry out their functions. The amount of energy a cell requires depends on its activity. An Olympic marathon runner's muscles are expanding and contracting for over 2 hours. The muscles require energy which is released by aerobic respiration.

Karl is investigating how exercise affects his breathing and pulse rate. He takes measurements before and after running on the spot for 3 minutes and records his results in a table.

	Pulse rate (beats per minute)	Breathing rate (breaths per minute)	Volume of air inhaled per breath (ml)
Before exercise	67	13	800
After 3 minutes' exercise	132	46	1600

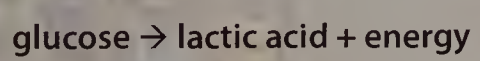
- 1 Describe the differences in Karl's pulse rate, breathing rate and depth of breathing before and after exercise.
- 2 How much more air per minute did Karl inhale after exercise?
- 3 By what percentage did Karl's pulse rate increase after 3 minutes of exercise?
- 4 Explain why Karl's breathing changed during exercise.

HINT Amount of air inhaled = number of breaths $\times$ volume of air inhaled per breath

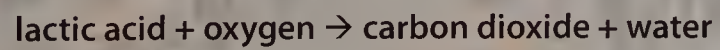


ANAEROBIC RESPIRATION

When muscles are working very hard, the circulation cannot deliver enough oxygen for all the energy needed to come from aerobic respiration. The extra energy comes from an alternative process – **anaerobic respiration** – in which glucose is broken down to lactic acid, releasing energy.

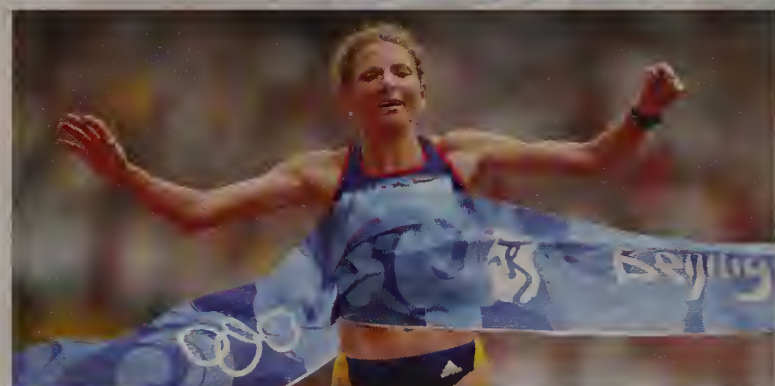


After exercise, the lactic acid is either converted back to glucose or broken down using oxygen.



The feeling of burning and pain in the muscles during vigorous activity may be caused by high levels of lactic acid and other metabolites. A runner cannot depend on anaerobic respiration for more than a few minutes. The pain forces them to slow down until the oxygen level rises and the acid is broken down, preventing damage to the muscles.

- 1 Why does anaerobic respiration occur?
- 2 In a marathon, many runners can still manage a 'sprint finish' at the end of the race. Where does this 'extra' energy come from?
- 3 Why can't a marathon runner sprint for the entire race?
- 4 Sketch a graph to show how energy requirements vary with exercise level. Plot 'Energy used' on the y-axis and 'Exercise level' (sedentary, gentle, brisk, vigorous) on the x-axis.
- 5 Why is 'Energy used' greater than zero even for a sedentary person?





14 000 m³ of soil was used to build the banks and jumps for the BMX Track in the Olympic Park.

BMX

POLLUTION

NETWORK INFRASTRUCTURE

DID YOU KNOW? The outdoor wireless network access points in the Olympic Park can operate at temperatures between -40°C and 55°C and in winds of up to 165 mph. 30% of Cisco's network infrastructure hardware will stay in place after the 2012 Games, to be used as part of London 2012's legacy.



WASTE

During any large event it is important to manage waste efficiently. Burying waste is not a sustainable option. Carbon dioxide is emitted during transport and burial of the waste. Other greenhouse gases are produced by decomposing landfill.

During the 2012 Games, the organisers plan for zero waste to go to landfill sites. They will limit the amount of packaging used for food and merchandise sold at the Olympic Park, and ensure that, where possible, the packaging can be recycled or composted. Waste that can't be recycled can be incinerated (burned) and the energy used for heating or generating electricity.

- 1 What are the problems associated with using landfill sites to dispose of waste?
- 2 How could London 2012 organisers reduce waste at the Olympic Park?
- 3 What are the benefits of recycling?
- 4 How might humans contribute to pollution at the Olympic Park? Give as many examples as you can, and explain your choices.





AIR POLLUTION

Motor vehicles release gases such as sulfur dioxide and nitrogen oxides into the atmosphere, which can cause pollution. London 2012 organisers are aiming for 100% of spectators to reach the Olympic Park by public transport, cycling or walking. Visitors to the Olympic Park will be able to use a wide range of bus and rail services.

Lichens are organisms that grow on trees and walls. Some lichens can only grow in low concentrations of atmospheric sulfur



dioxide and nitrogen oxides. These lichens can be used as indicator species for levels of air pollution.

- 1 How will use of public transport rather than cars keep air pollution near the Olympic Park to a minimum?
- 2 The Olympic Park will continue to develop after the 2012 Games. Describe how organisers could use indicator organisms to investigate changes in air pollution at the site before and after London 2012.
- 3 Explain why an investigation of pollution levels at the Olympic Park is not necessarily a reliable measure of air pollution produced at the Park.



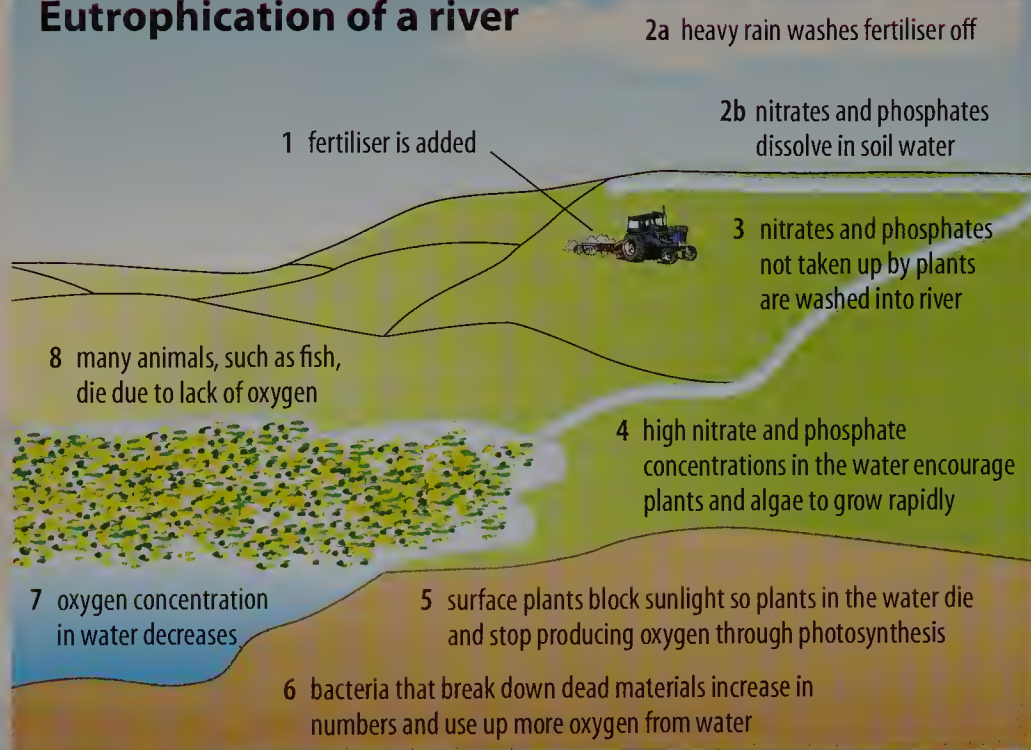
WATER POLLUTION

The River Lea flows through the Olympic Park. During construction of the Park, dredging of the river to remove silt, gravel and rubbish improved the water quality. Three Mills Lock was built to maintain a minimum depth of water and to keep out tidal salt water from the River Thames.

The presence of invertebrates such as dragonflies indicates good water quality with plenty of oxygen. Reduced oxygen concentration in the water, e.g. caused by **eutrophication**, kills many species and provides conditions suited to only a few specialised species such as bloodworms.

- 1 The River Lea flows through farmland north of London. Describe how this might affect the water quality at the Olympic Park.

Eutrophication of a river



- 2 Design an experiment to investigate the water quality in a river. Describe how you would carry out your investigation and how you would record your results.



SYNCHRONISED SWIMMING

ENERGY TRANSFER BY HEATING

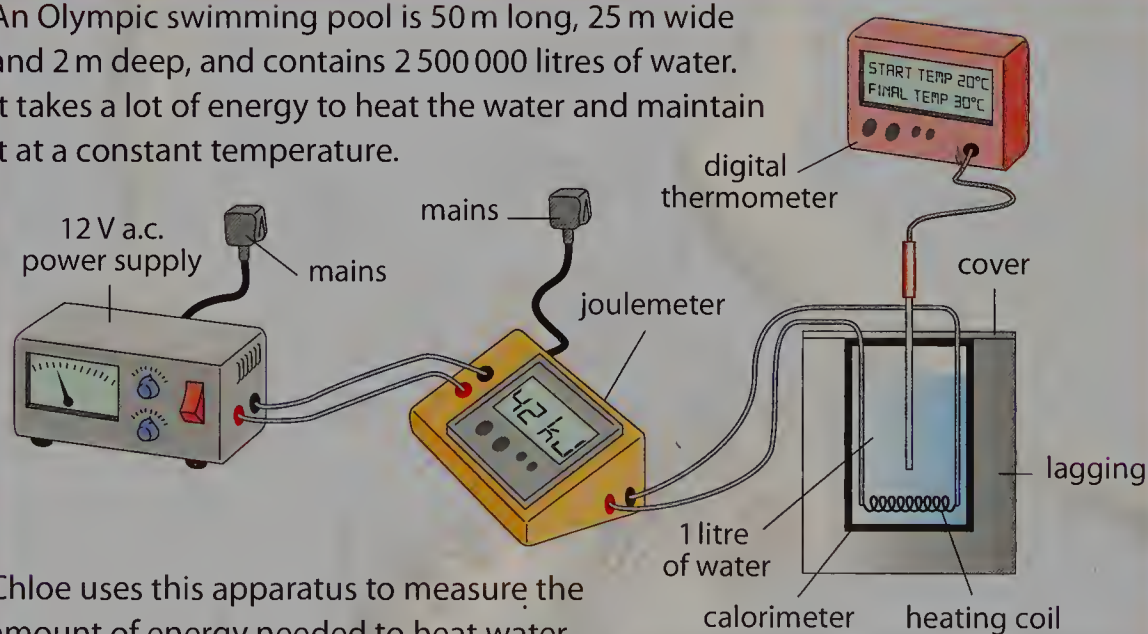
NETWORK INFRASTRUCTURE

DID YOU KNOW? Larger surface areas can be cooled more easily than smaller surface areas. Heat sinks attached to the processors in the firewalls of Cisco's network infrastructure increase the exposed surface area. Fans move air across the heat sink, keeping the processor cool.



HEATING THE POOL

An Olympic swimming pool is 50 m long, 25 m wide and 2 m deep, and contains 2 500 000 litres of water. It takes a lot of energy to heat the water and maintain it at a constant temperature.



Chloe uses this apparatus to measure the amount of energy needed to heat water. Her results are shown in the diagram.

- 1 Use Chloe's results to calculate the specific heat capacity of water.
1 litre of water has a mass of 1 kg.
- 2 What is lagging?
- 3 Why is lagging important in this investigation?

HINT

The **specific heat capacity** of a material is the energy needed to increase the temperature of 1 kg of the material by 1 °C. You can calculate specific heat capacity using this equation:

$$\text{specific heat capacity (J/kg } ^\circ\text{C)} = \frac{\text{energy transferred (J)}}{\text{mass (kg)} \times \text{temperature change (} ^\circ\text{C)}}$$

The synchronised swimming will take place in the Aquatics Centre, which contains two swimming pools and a diving pool.

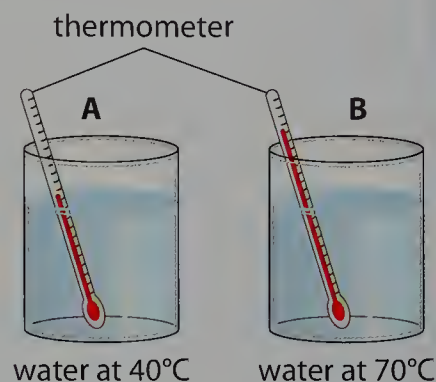


COOLING WATER

The swimming pools in the Aquatics Centre are constantly transferring thermal energy to the surroundings. The rate of cooling will depend on the surface area of the pools and the difference in temperature between the water and the surroundings.

Chloe recorded the temperature change in two beakers of water over 10 minutes.

	Initial temp. (°C)	Final temp. (°C)
A	40	30
B	70	50



- Each beaker contained 0.5 litre of water. Use this equation to work out how much thermal energy each beaker transferred to its surroundings.

energy transferred = specific heat capacity × mass × temperature change

- Explain how the temperature difference between an object and its surroundings affects the rate of energy transfer.

Chloe repeated the investigation, this time blowing air across the tops of the beakers.

	Initial temp. (°C)	Final temp. (°C)
A	40	25
B	70	43

- What was the temperature change for each beaker with the air blowing?
- How much thermal energy did each beaker transfer to its surroundings?
- Explain why an outdoor swimming pool cools more quickly on a windy day.



WRITING CONCLUSIONS

Convection currents contribute to the heat loss from the Olympic Pool. They can be reduced by covering the surface of the swimming pool when it is not in use.

- Draw a diagram showing the convection currents in the water and the air when the pool is not covered.
- Write a letter to the Olympic Delivery Authority recommending the use of a pool cover and explaining, in terms of particles, how the pool cover reduces energy losses from the pool. Consider all the energy transfers that are taking place.

Underwater speakers allow the synchronised swimmers to hear the music throughout their routines.



GYMNASTICS

GENES AND INHERITANCE

NETWORK INFRASTRUCTURE

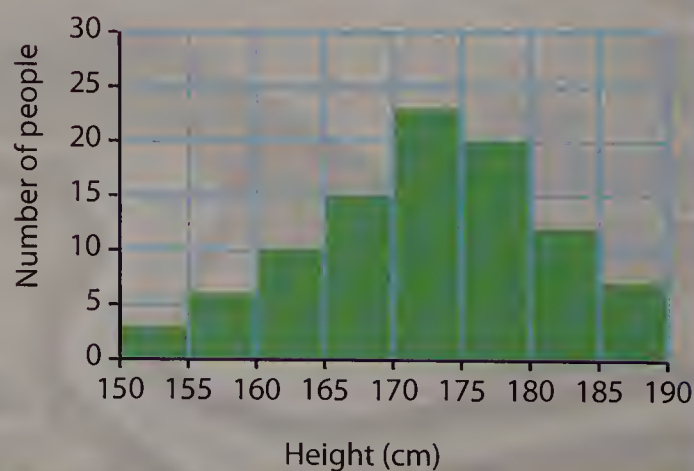
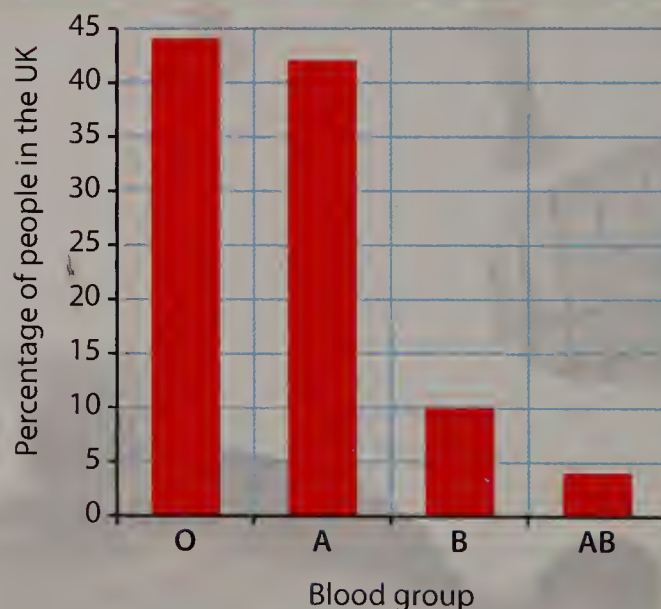
DID YOU KNOW? Cisco's network infrastructure will link the North Greenwich Arena to the Olympic Park. Cisco engineers estimated the maximum bandwidth necessary for critical voice and data communications. Then they provided double that amount, to make sure everything runs smoothly!



VARIATION

Some characteristics, such as natural hair colour, are inherited from our parents. Other characteristics are affected by the environment. A good example is body mass which depends on how much we eat and exercise. Many characteristics develop as a combination of genetic and environmental factors.

- 1 These human characteristics show variation.
a hair length **b** eye colour **c** height
 Is the variation in each of these characteristics caused by genes, environment or both? Explain each of your answers.
- 2 Read the information on Nastia Liukin. Explain how Nastia's ability as a gymnast could be the result of her
a genes **b** environment
c genes and environment together.
- 3 Some characteristics, such as height, show continuous variation. Other characteristics, such as blood group, show discontinuous variation.
a Use the graphs to help you explain what is meant by continuous and discontinuous variation.
b Suggest one other human characteristic that shows continuous variation, and one that shows discontinuous variation. Explain your answers.



North Greenwich Arena, originally built for the Millennium celebrations, will be used for the London 2012 Artistic Gymnastics and Trampoline Gymnastics.

At the Beijing 2008 Games, Nastia Liukin of the USA won the Gold Medal in the women's All-Around Artistic Gymnastics.



Nastia is the daughter of two champion Russian gymnasts. Her father was an Olympic Gold Medallist in 1988, and her mother was a World Champion artistic gymnast. When Nastia was very young, they took her to the gym where they worked. She started to copy what the children did in their lessons. Nastia showed great talent, and entered her first competition at the age of six.



ALLELES

A gene is a short piece of DNA that codes for a characteristic or protein. Different forms of the same gene are called alleles. Different alleles produce variations of the characteristic. For example, different alleles for a gene that codes for hair colour might produce red hair or brown hair.

We have two alleles for each gene. If both alleles are the same, you are homozygous for that gene. If they are different, you are heterozygous. If a characteristic is only produced when both alleles are the same, the allele is said to be recessive. If only one allele is needed to produce a characteristic, the allele is dominant.

This Punnett square shows the inheritance of the alleles for hair colour. The allele for brown hair is shown as R and the allele for red hair is shown as r.

		Father's alleles	
		R	r
Mother's alleles	R	RR brown	Rr brown
	r	Rr brown	rr red

- Say whether each parent is (i) heterozygous, (ii) homozygous for brown hair, or (iii) homozygous for red hair. Explain your answer.
- The black outline shows the possible offspring from these parents. What is the probability that their child will be
a red-haired b brown-haired?
- Which of these two alleles is recessive? Explain your answer.
- Explain why it would be possible for this couple to have four red-haired children.



INVESTIGATING GENOTYPES IN ATHLETES

Scientists have studied elite athletes to see if they carry alleles which make them better able to win races than other people. One gene that has been linked with athletic performance is the angiotensin-converting enzyme (ACE) gene. One allele of this gene (called I) is associated with greater endurance during physical training, and another (called D) is associated with greater ability to sprint at high speeds.

A study of 33 elite Italian gymnasts and 53 unrelated sedentary people showed the following results for the proportions of individuals with different genotypes.

	DD	ID	II
Gymnasts	0.39	0.48	0.12
Sedentary	0.39	0.45	0.15

- What do the results show about the proportions of each group with the different genotypes? Explain your answer.
- Do these results suggest that there is a link between particular ACE alleles and gymnastic performance?
- Imagine Nastia Liukin had an identical twin (who would have the same genes as Nastia). Would her twin be as good as, better than or worse than Nastia at gymnastics? Explain your answer as fully as you can.



PARALYMPIC ROAD CYCLING

ENERGY TRANSFERS

NETWORK INFRASTRUCTURE

DID YOU KNOW? Brands Hatch is one of around 100 venues which will be linked using the London 2012 network. With cyber attacks on the increase, it's crucial that Cisco make sure the network is secure. Cryptographic keys protecting critical systems have 16^{32} combinations. Trying every combination would take billions of years, even using the most powerful computers in the world.



WORK DONE AND POWER

As a cyclist travels around the 7.5 km Brands Hatch Paralympic Road Cycling course, she is doing work. The amount of work can be calculated using this equation:

$$\text{work done (J)} = \text{force (N)} \times \text{distance moved (m)}$$
$$E = F \times d$$

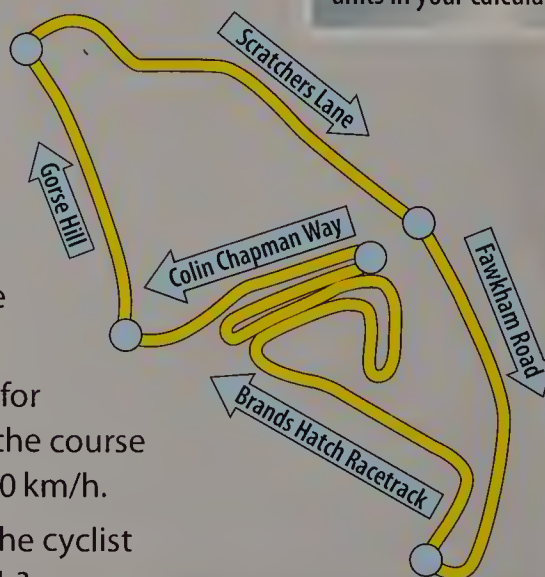
The cyclist's power is the rate of doing work. It is measured in watts (W) and can be calculated using this equation:

$$\text{power (W)} = \frac{\text{work done (J)}}{\text{time taken (s)}}$$
$$P = \frac{E}{t}$$

HINT

Make sure you use the correct units in your calculations.

- 1 To maintain a constant speed, the cyclist needs to maintain an average force of 50 N. How much work is done to complete one circuit?
- 2 Calculate the time (in seconds) taken for the cyclist to complete one circuit of the course if she travels at an average speed of 30 km/h.
- 3 What is the average power output if the cyclist travels at an average speed of 30 km/h?



British athlete Rachel Morris tests out the Paralympic Road Cycling course at Brands Hatch. Parts of the race will take place on the old Formula 1 racetrack.

ON THE WEBSITE
Watch Rachel talk about the Brands Hatch course and her training regime.



GRAVITATIONAL POTENTIAL ENERGY

The Paralympic Road Cycling course has been praised for its challenging hills. Although no climb is more than 5%, the course climbs from a low point of 125 m to a high point of 170 m above sea level.

Energy gained from an object's position is called gravitational potential energy (GPE) and can be calculated using this equation:

$$\begin{aligned}\text{GPE (J)} &= \text{mass (kg)} \times \text{gravitational field strength (N/kg)} \times \text{vertical height (m)} \\ &= m \times g \times h\end{aligned}$$

On Earth, the gravitational field strength is approximately 10 N/kg.

- 1 The combined mass of Mark and his cycle is 72 kg. Using the equation above, calculate the change in GPE as he cycles from the lowest point on the course to the highest point.
- 2 The principle of conservation of energy states that energy cannot be created or destroyed. The energy Mark transfers in climbing from the lowest point to the highest point on the course is 45 kJ. Identify all of the forces involved and explain why this is not the same as the change in GPE.



KINETIC ENERGY

Moving objects have kinetic energy which can be calculated using this equation:

$$\begin{aligned}\text{kinetic energy (J)} &= \frac{1}{2} \times \text{mass (kg)} \times \text{velocity}^2 \text{ (m/s)}^2 \\ \text{KE} &= \frac{1}{2} \times m \times v^2\end{aligned}$$

Note that velocity is a vector quantity. It is speed in a given direction. The combined mass of Abigail and her cycle is 67 kg. She freewheels down a hill from a height of 80 m.

- 1 Calculate Abigail's GPE at the top of the hill.
- 2 Estimate Abigail's velocity at the bottom of the hill. Assume all her potential energy has been converted into kinetic energy.
- 3 Abigail's actual velocity at the bottom of the hill was 45 km/h.
 - a Calculate the difference in energy between your estimated velocity and the actual velocity.
 - b Explain why all the GPE is not transferred to kinetic energy.
- 4 Identify all of the energy transfers occurring as Abigail completes one circuit of the Brands Hatch course.

Paralympic Cycling was originally developed as a sport for blind athletes, who first competed using tandem bicycles. It is now the third largest Paralympic sport.



PENTATHLON

ELECTRICAL CIRCUITS

NETWORK INFRASTRUCTURE

DID YOU KNOW? Computer chips are just complicated electrical circuits, called 'integrated circuits'. Cisco use application-specific integrated circuits (ASICs) in their network switches to forward packets of data.

The Modern Pentathlon is based on a 19th-century legend about a young French cavalry officer who was sent on horseback to deliver a message. To achieve his mission, the officer had to ride, fence, shoot, swim and run. These are the five events for competitors in the Modern Pentathlon.

FELL
GBR

205



ON THE WEBSITE

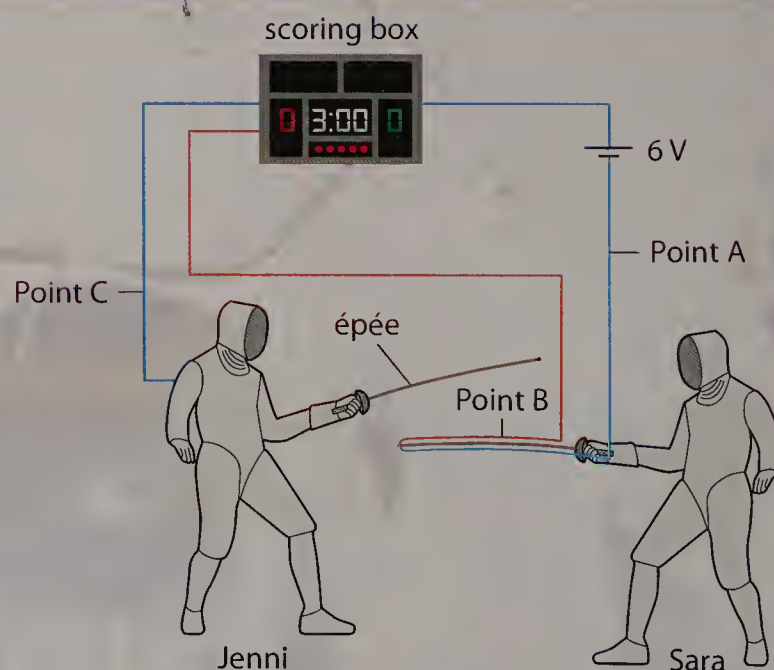
Watch British Fencer Richard Kruse talk about how circuits are used to keep score in fencing.



CIRCUITS

In fencing, scores are recorded electronically. The diagram shows a scoring circuit. The épée (weapon) is connected to the scoring box and a 6 V battery. The target area includes the opponent's entire body, but excludes their weapon and the floor. The épée ends in a push-button. For the scoring box to register a valid hit, the épée must contact the target with a force of at least 7.35 N and the push-button must remain fully depressed for 1 ms.

- 1 Draw a circuit diagram to show how you would measure
 - a the potential difference across the battery
 - b the current through Sara's equipment
 - c the current through Jenni's equipment.
- 2 When the tip of Sara's épée is depressed on Jenni's suit the circuits are closed. The current at Point A is 10 mA and at Point C is 7 mA. Work out the current at Point B. Explain your answer.



- 3 There is a broken wire at Point B in Sara's épée. What current flows through Point A when she makes
 - a a valid hit
 - b an off-target hit?

Fencing forms part of the Modern Pentathlon, along with swimming, riding, shooting and running.



CURRENT AND RESISTANCE

The resistance of a circuit is a measure of how easy it is for the current to flow. Resistance is measured in ohms (Ω). The potential difference (p.d.) is supplied by one 6V battery.

- 1 Copy and complete the table comparing current and resistance in the fencing circuit using this equation:

$$\text{p.d. (V)} = \text{current (A)} \times \text{resistance } (\Omega)$$

- 2 Use the data in your table to draw a line graph to show how current varies with resistance.
- 3 The equipment is specified to have a maximum resistance of 450Ω . Use the equation above to calculate the minimum current that would flow in this circuit.

Resistance (Ω)	Current (mA)
12	500
30	
60	
120	
300	
600	
1200	



VOLTAGE AND CHARGE

The coulomb (C) is the unit of charge, defined as the charge passing a point in a wire in one second when the current is exactly 1 A. You can use this equation to calculate charge:

$$\text{charge (C)} = \text{current (A)} \times \text{time (s)}$$

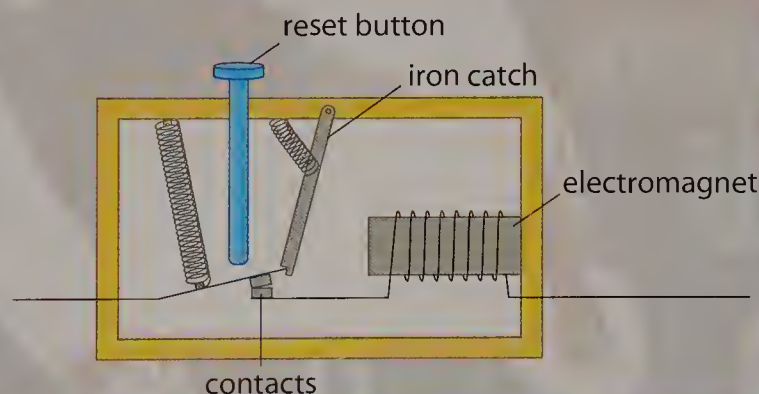
$$Q = I \times t$$

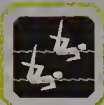
The potential difference across the scoring box is equal to the work done in moving 1 C of charge through it. The work done in moving 1 C of charge through a potential difference of 1 V is 1 J. You can calculate the energy transferred (work done) using this equation:

$$\text{energy transferred (J)} = \text{charge (C)} \times \text{potential difference (V)}$$

- 1 The tip of the épée is depressed for 10 seconds.
 - a What charge will pass through Point A in the fencing circuit (Bronze question 2)?
 - b How much energy is transferred to the scoring box?

- 2 The 6 V battery is replaced with a 12 V battery. How much energy would be transferred through the scoring box if a valid hit was in contact with the target for 0.5 second?
- 3 The mains supply is 240 V. Use your results from questions 1 and 2 to explain why it would be dangerous to connect the fencing circuit to the mains supply.
- 4 The diagram below shows a circuit breaker which is used to protect against high currents. Describe how the circuit breaker works.





The Energy Centre located in the west of the Olympic Park will help generate the thermal energy needed to heat the Aquatics Centre swimming pools and other venues.

ENERGY CENTRE

GENERATING ELECTRICITY

NETWORK INFRASTRUCTURE

DID YOU KNOW? The London 2012 telephone network uses Cisco's 'Power over Ethernet' (PoE) technology. Instead of using separate transformers, power is delivered to each telephone through the same cable as the signal. This saves energy, helping to make London 2012 the greenest Games ever.

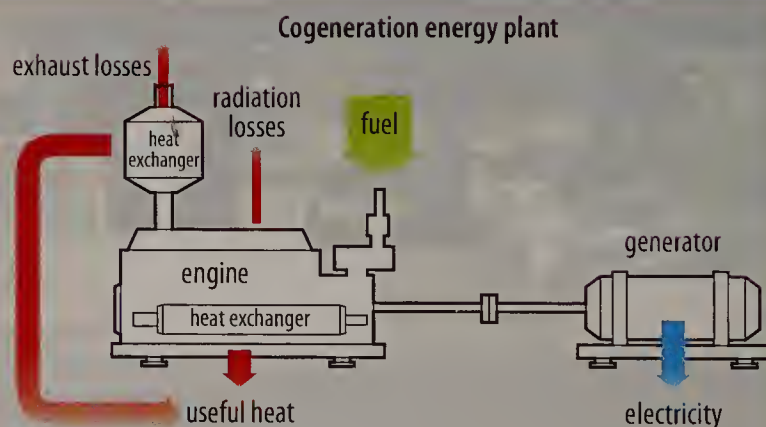


ENERGY TRANSFER

The Olympic Park requires energy. The organisers have aimed to be 'mean, lean and green', by reducing the environmental impact of the London 2012 Games.

- The text below describes some of the energy transfers which take place in a gas engine cogeneration plant like the one on the Olympic Park. Copy the text and fill in the gaps using the words **electrical**, **kinetic**, **chemical**, **thermal** and **combustion**.

Natural gas is used as the fuel for the cogeneration plant on the Olympic Park. _____ energy stored in the natural gas is released in a process called _____. This energy is then converted into _____ energy in the moving pistons in the engine. The pistons in the engine turn a drive shaft which is attached to a generator. In the generator, _____ energy in the drive shaft is converted into useful _____ energy. In a normal engine, _____ energy is lost through the exhaust



and the body of the engine. In a cogeneration plant, this _____ energy is captured, and used to provide heating and cooling for the buildings in the Olympic Park.

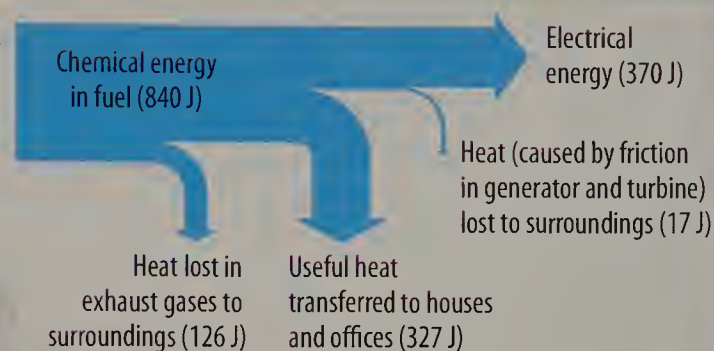
- In a traditional power plant, water is heated in a boiler to produce steam. This steam turns a turbine which is attached to a generator, producing electrical energy. The steam is then condensed (to water) and returned to the boiler. Describe some of the benefits of cogeneration over traditional power plants.

The London 2012 Energy Centres will use a technique of energy production called cogeneration. Instead of using a separate electricity generator and boiler, heat used to generate electricity will also be used to heat water and buildings. Cogeneration is a very efficient way of generating heat and power.



ENERGY CONVERSION

- Look at the Sankey diagram for a cogeneration power plant. What is the total useful energy (joules) produced?
- What is the total energy lost to the surroundings?
- A traditional power station with an input energy of 840 J produces 400 J of electrical energy. The heat lost to the surroundings (caused by friction in the generator and turbine) is 17 J.
 - Calculate the heat lost in exhaust gases.
 - Draw a Sankey diagram to represent the energy input and output for the traditional power station.



EFFICIENCY

The efficiency of a power station is the proportion of energy transferred from the fuel into useful forms. New cogeneration power plants have a net efficiency of about 80%. You can use this equation to calculate efficiency:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$$

- Use information from the Sankey diagram (Silver question 1) to calculate the efficiency of the cogeneration power plant for
 - electrical energy
 - useful heat transferred
 - overall efficiency.
- Thermal energy from the cogeneration power plant is used to heat water in the Aquatics Centre. Using your knowledge of conduction and efficiency, explain why the organisers sited the Energy Centre near the Aquatics Centre.
- Traditional gas-fired power stations are generally sited in a remote location whereas cogeneration plants are built close to the area they serve. Explain the pros and cons of a cogeneration power plant compared to a traditional power plant in
 - a city such as London
 - a rural location.

After the 2012 Games, the two Energy Centres will be able to provide electricity and heat for around 20 000 homes, helping to reduce carbon emissions by up to a quarter compared to conventional heat and electricity generation.

LEGACY AND SUSTAINABILITY

1 THE OLYMPIC STADIUM

NETWORK INFRASTRUCTURE

DID YOU KNOW? Cisco's reliable and efficient network infrastructure plays an important role in the sustainability of the 2012 Games. London 2012 organisers have used Cisco's lightning-fast network connections, IP telephones and video conferencing to stay in touch, reducing the need for air travel and reducing carbon emissions.

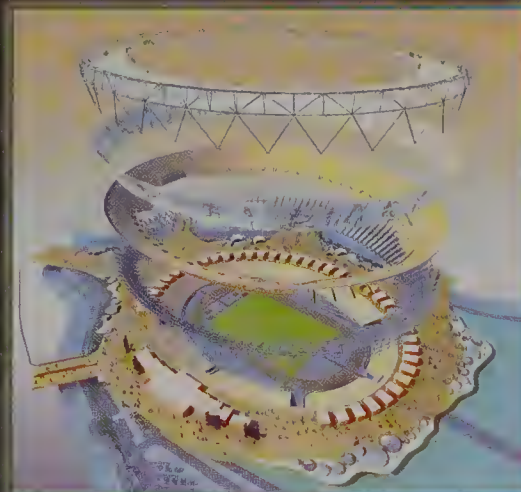
On these two pages you can see some of the innovations and decisions that helped make the London 2012 Olympic Stadium the most sustainable ever built.

Record breaking roof makes world records more likely

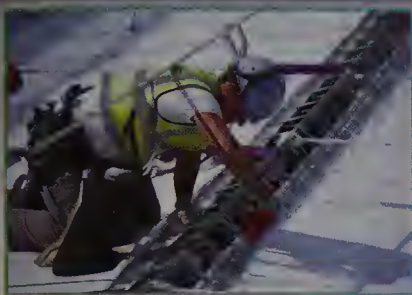
Wind conditions can make a big difference to world record attempts. In the 100m Sprint a following wind of more than 2 m/s would mean that no official world records could be set. And if the sprinters were running into a 2 m/s headwind they would find it very difficult to run record times.

The Olympic Stadium designers looked very carefully at how the shape of the stadium would affect wind speeds inside. Initial plans for the stadium didn't include a roof. But a powerful computer model showed that the roof could help reduce wind speeds inside the stadium, making world records more likely.

Engineer Tanya Ross talks about solving the problem: "You build a computer model and blow computer wind at it. It will tell you what the wind speed will be at any point inside the stadium."



The stadium is part buried in the ground, with the field of play set as low as flood levels will permit. By incorporating the bottom 25 000 seats into the landscaping of the Olympic Park, the amount of steel required for the structure was drastically reduced.



The stadium roof is created from a network of steel cables, which reduces the amount of heavy, expensive

steelwork required. The entire stadium only uses 10 000 tonnes of steel. This is less than 10% of the amount used for the Beijing 2008 stadium.

Some of the biggest steel tubes are made from reclaimed gas pipes.



ON THE WEBSITE

Watch the Olympic Stadium being built in a time-lapse sequence.

CHALLENGE 2012



PUT SUSTAINABILITY INTO PRACTICE BY PLANNING AN EVENT NEAR YOUR SCHOOL

Cisco is running a competition challenging schools to design a major sporting event in their area.

To get involved, go to

www.mathsandscience2012.co.uk/challenge2012

There is more information on page 11.

Saving water at London 2012

The 2012 Games are estimated to use 1 152 000 litres of water each day. Water usage is a very important consideration when constructing any sustainable building. Here are some of the measures used in the Olympic Stadium to reduce water usage.

- Dual-flush toilets using only 4.5 litres per flush
- Waterless urinals
- Low-flow showers with a maximum flow rate of 6 litres per minute
- Low-flow taps with a maximum flow rate of 0.08 litres per second

Science Skills

- 1 Many materials can be recycled or reused. However, some materials cannot be recycled or reused and are usually buried in landfill.
 - a Choose at least three different materials. For each one, identify its use at the Olympic Stadium, whether it will be temporary or permanent, and what will happen to it afterwards (recycled, reused or buried).
 - b What material is best suited for underground pipes carrying water and electrical cables? Explain your choice.
 - c Titanium is as strong as some steels, but 45% lighter. What other factors do engineers need to consider when choosing building materials?
- 2 The Olympic Stadium is designed to keep wind out and so allow records to be broken. Explain why designers used computer models to help design the Olympic Stadium.

The external structure of the stadium will be covered by a temporary 'wrap', which is much lighter than traditional cladding. It will shelter spectators inside the stadium from the weather.

LEGACY AND SUSTAINABILITY

2 THE OLYMPIC PARK

NETWORK INFRASTRUCTURE

DID YOU KNOW? Up to 30% of the network infrastructure hardware Cisco will install on the Olympic Park will remain after the 2012 Games. This equipment will provide network connectivity for the thousands of future users of the Olympic Park, helping to contribute to the legacy of London 2012.

Sustainability is about more than just environmental responsibility and minimising waste. It means creating a 2012 Games which is accessible to a wide range of people of different backgrounds and abilities. It is about creating new employment and business opportunities, and providing a lasting legacy for the local area and beyond.

£1 billion Athletes' Village will be transformed after the 2012 Games

During London 2012 the Athletes' Village will provide accommodation for around 17 000 athletes and officials. The £1 billion development will be used after the 2012 Games to provide 2818 new homes for East London. Residents will benefit from the improved transport links created for the 2012 Games, new schools and utilities, and one of the largest urban parks built in Europe for 150 years.



ON THE WEBSITE

Watch videos showing the Olympic Park during the early stages of construction.

Olympic Park will be accessible for all

Up to 8% of spectators at London 2012 are expected to have difficulty negotiating stairs or escalators. With up to 20 000 mobility-impaired spectators a day visiting the Olympic Park during the 2012 Games, it is essential to consider how accessible the venues and facilities are. Engineers used cut-and-fill techniques to make sure the vast majority of the Park had no slopes steeper than 1 in 60.

In the five London boroughs adjoining the Park, at least 23% of the population require washing facilities before prayer. To meet the needs of different faith groups, at least one cubicle in each toilet block on the Olympic Park will contain a footbath with a spray hose.

This image is illustrative only and indicative of the aspirations for the future Park and should be viewed as such. It will be subject to change as plans for the Park and area develop over time.

The Olympic Park is at the heart of London 2012. The 150-acre site contains nine of the venues for the 2012 Games, including the Olympic Stadium, the Velodrome, the Aquatics Centre and the Basketball Arena.

Engineers built a 'soil hospital' to clean the site

Soil contamination was a huge issue on the Olympic Park. Tanneries, coal tar works and paint factories had all used the site, and the area had been a dumping ground for rubble after World War Two bombings.

In order to reuse soil from the site, a 'soil hospital' was set up. A set of 50-tonne machines washed, sieved and shook contamination out of the soil. Tar, cyanide, petrol and lead were all removed. The cleaned soil was tested to make sure it was safe, and then reused on the Olympic Park.



Transforming the lives of people throughout the UK

Promoting healthy living is an important part of creating a sustainable 2012 Games. The creation of 50 km of new cycle routes and 30 km of new walking routes will improve access to and around the Olympic Park. With nearly three-quarters of car journeys in the UK being less than five miles, walking and cycling are ideal ways of saving time and money whilst exercising.



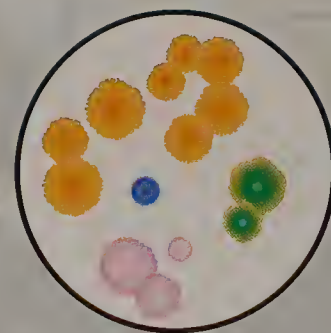
The London 2012 Changing Places programme encourages volunteers to carry out projects to improve their local communities. The projects are centred on the host boroughs, and include creating new habitats for birds and bats and planting trees.

Over 30 000 jobs will be created during construction for London 2012, including at least 350 apprenticeships. During the 2012 Games more than 100 000 people will be employed in jobs including catering, cleaning and security.

Science Skills

- 1 There are three swimming pools in the Aquatics Centre and two in the Water Polo Arena. With more than 2000 athletes using them over the four weeks of London 2012, it is vitally important to make sure that the water is clean and safe.

Chloe spreads a sample of pool water on a Petri dish to check the quality of the water.



- a How many different types of bacteria are present?
- b What else does Chloe need to know about the bacteria before she can decide if the water is safe?
- 2 There are many areas where health and safety risks need to be considered at the Olympic Park. Identify three areas of risk and explain how these risks can be minimised.

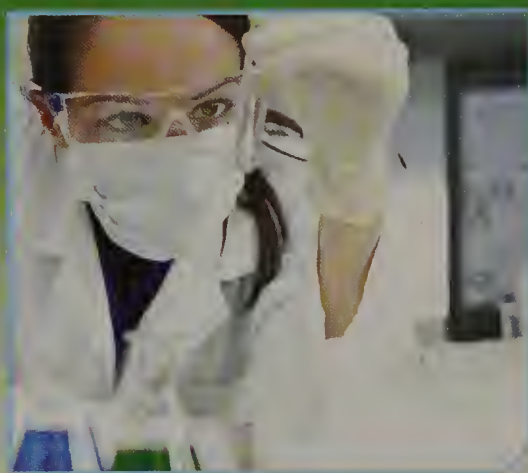
TRANSFORMING YOUR FUTURE

1 QUALIFICATIONS IN MATHS AND SCIENCE

Without the maths and science skills of thousands of engineers, architects, project managers, sports scientists, accountants, lawyers, technicians, builders and IT experts, the London 2012 Olympic and Paralympic Games could never exist.

Maths and science are everywhere, from the food you eat and the clothes you wear, to the software that lets you check your email or text your friends.

Qualifications in maths and science can open the door to more exciting jobs and higher salaries. They can also give you a leg-up when you're looking for a university or college place.



Maths and science qualifications can give you more choices when looking for jobs or university or college places.

Why study maths and science post-16?

- ✓ **Get a head start in other subjects**
Economics, ICT, sports science and geography all use maths and science.
- ✓ **Impress admissions tutors**
Whichever subject you apply for at university or college, an A-level or Higher in maths or science will help you stand out from the crowd.
- ✓ **Land a great job**
Science helps you develop communication and team-working skills that will impress potential employers.
- ✓ **Earn more**
Graduates and non-graduates who have an A-level or Higher in maths tend to earn more than those of similar ability and background who don't.
- ✓ **Increase your options**
With a qualification in maths or science you're likely to have more choice at university or college, and when you're looking for a job.
- ✓ **Learn to solve problems**
Science and maths are all about understanding how the world works and using that knowledge to solve problems.

POST-16 SPOTLIGHT: MATHS

Students study algebra, geometry and calculus as well as options from statistics, mechanics and decision maths. Decision maths has lots of applications in computer programming. And you can use mechanics to work out how fast a roller coaster needs to travel to keep everyone in their seats!



POST-16 SPOTLIGHT: PHYSICS

Physics students get hands-on with radioactivity, electricity and magnetism. You can build electric motors, use lasers and learn how particle accelerators work, recreating experiments which inspired well-known physicists like Professor Brian Cox.



Cisco Networking Academy

The Cisco Networking Academy is a global education programme which teaches students how to design, build, troubleshoot and secure computer networks. Students complete hands-on learning activities and network simulations to develop the practical skills needed for ICT and networking careers in virtually every type of industry. Students also develop essential workplace skills such as problem-solving, collaboration and critical thinking.

There are more than 350 schools, universities and colleges in the UK which offer courses from the Cisco Networking Academy, giving students an opportunity to develop ICT literacy skills, and work towards future careers in IT or networking.

Visit <http://cisco.netacad.net> for more information.

POST-16 SPOTLIGHT: CHEMISTRY

Chemistry is the study of matter. Chemistry gives us clean water, medicines and technologies like flat-screen televisions. Chemistry students learn about the atomic structures of molecules, finding out how chemical reactions in a car's catalytic converter can help to reduce harmful emissions.



POST-16 SPOTLIGHT: BIOLOGY

Biology students learn about the building blocks of life, and how genetics and stem-cell research are shaping the future of medicine. Studying biology is a crucial step to becoming a doctor, dentist, nurse or vet, and can also lead to careers in agriculture, psychology, robotics, forensic science and physiotherapy.



PROFILE: DAVID KONOPEK THE SYSTEMS ANALYST

Technology enthusiast David Konopek turned to the Cisco Networking Academy when he decided he was interested in a career in ICT. "Networking skills are in demand throughout the world," says David, "and people who are Cisco certified don't worry too much about getting a job."

Through the Academy, David earned his Cisco Certified Networking Associate qualification. "It was a great mix of theory and practical experience that was highly stimulating," he recalls.

After graduating, David had the know-how and confidence he needed to start his own business. David's working life offers a great deal of variety and flexibility, thanks to a wide range of skills and experience – and he is currently taking steps to expand his qualifications. "Now I am building up my own business," he says. "I have also enrolled in a distance-learning university programme, in order to obtain a bachelor's degree in Business ICT." David plans to return to the Cisco Networking Academy to complete a more advanced qualification in the future.

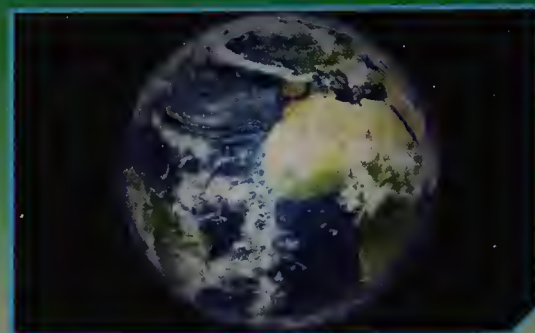
TRANSFORMING YOUR FUTURE

2 CAREERS IN MATHS AND SCIENCE

The world we live in is changing. The internet has transformed the way we live, work and communicate. People are living longer and moving more freely between countries. And our climate may be changing too.

To seize the opportunities and solve the problems associated with these changes, there is a need for people with maths and science skills: engineers, chemists, doctors, computer scientists, physicists and countless others who will all contribute to the world's future.

Training in maths and science will help you play your part, and these fundamental skills will give you the flexibility to explore different careers throughout your life.



Old technologies are still creating some of our planet's greatest problems. New technologies will help solve them.



ON THE WEBSITE

Watch Tim Brabants talk about his medical career and success at Beijing 2008.

PROFILE:
TIM BRABANTS
OLYMPIC GOLD
MEDALLIST AND
MEDICAL DOCTOR

Weeks after winning a Gold Medal in the Men's 1000 m Kayak event at Beijing 2008, qualified medical doctor Tim Brabants returned to his job in A&E at Queen's Medical Centre in Nottingham.

After getting three As at A-level Tim chose to study at the University of Nottingham, which has a great reputation for medicine as well as fantastic kayaking facilities. "Medicine and sport have a lot in common," says Tim. "As a doctor, I work in a team."

Tim has taken a break from life as a doctor, taking advantage of help from sponsors like Cisco to focus his efforts on London 2012.

He was awarded an MBE in 2009.



**PROFILE: CECILIA
BAGENHOLM**
BUILDING DOCTOR

Cecilia Bagenholm is a senior consultant at the engineering company Buro Happold. She makes sure that Buro Happold's engineering projects meet environmental standards and don't have a negative impact on plant and animal life.

Maths and science skills opened up a huge range of careers, and it was environmental issues that Cecilia chose. Maths and science A-levels led to a degree in civil engineering at Imperial College, London. This was followed by an MSc in environmental technology and a career working around the world to develop standards for environmentally-friendly houses.



ON THE WEBSITE

Watch Richard Kruse talk about London 2012 both as an engineer and a medal hope.

PROFILE:
RICHARD KRUSE
OLYMPIC FENCER
AND ENGINEER

Richard Kruse is Britain's most successful fencer in almost 50 years, and has already competed in two Olympic Games. He is also a qualified civil engineer.

Richard completed his degree at City University in London in the same year that he represented Team GB in the Athens 2004 Games. "Fencing and engineering both require a logical mind," says Richard. While working for engineering company Buro Happold, Richard contributed to the design of the Olympic Park. "I worked on accessibility for the disabled, making sure there are enough rest stops," he says. Richard plans to make the most of his home advantage in the foil event at London 2012.

Transforming technologies

As the world's population increases, the demands we make on resources and the environment increase. Scientists are constantly working to develop new solutions for everything from generating electrical power to recycling waste materials. With skills in maths and science you could play a crucial role in developing technologies and ideas which will help future generations. *What will your legacy be?*

Maths and science in the 21st century

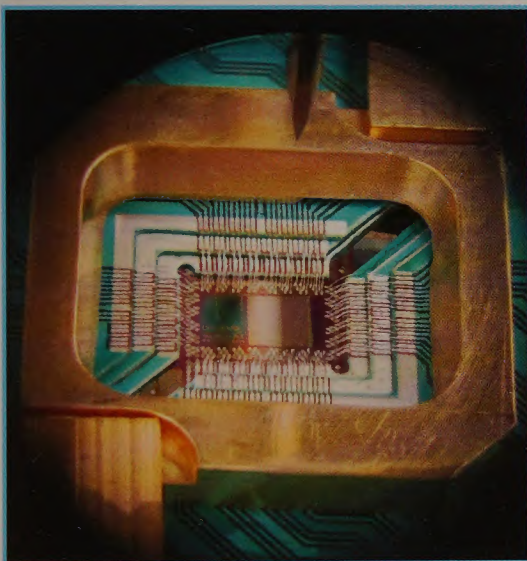
RENEWABLE ENERGY

To reduce our reliance on dwindling supplies of polluting fuels, such as oil, gas and coal, we need to develop renewable energy technologies. This solar power plant uses mirrors shaped like a quadratic curve to reflect sunlight on to a tube of heat-absorbing fluid.



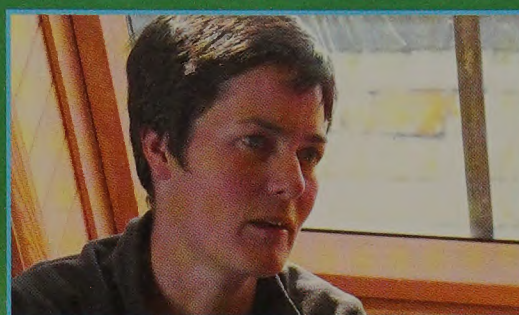
QUANTUM COMPUTING

Mathematicians and computer scientists are learning how to use strange quantum properties of subatomic particles to make lightning-fast computers. Modern encryption is based on prime numbers and factorisation. It would take thousands of years to factorise a 300-digit number using a conventional computer. A quantum computer could do it in seconds, making most modern codes useless.



FLEXIBLE E-PAPER

Can you imagine a world without paper? Engineers and scientists are developing flexible screens which you can roll up and carry in your pocket. These light, low-powered displays could replace computers, printers and paper in the near future.



ON THE WEBSITE

Watch Ellen MacArthur talk about her career transformation from sailor to campaigner.

PROFILE: ELLEN MACARTHUR ROUND-THE-WORLD YACHTSWOMAN NOW INSPIRING RE-THINKING AND RE-DESIGN

Ellen MacArthur first hit the headlines in 2001 when she secured second place in the Vendée Globe round-the-world sailing race at the age of only 24. She went on to become the fastest person to circumnavigate the globe single-handed, when in 2005 she sailed around the world in just 71 days and 14 hours.

She is a founder of the Ellen MacArthur Trust, set up in 2003, a charity which takes young people recovering from cancer and other serious illnesses sailing. She was knighted by the Queen in 2005, and following four years of research and having spent time working with government and key industry sectors, she retired from professional sailing to set up the Ellen MacArthur Foundation. The Foundation links education and business to inspire young people to re-think and re-design their future through the vision of a circular economy.

Turn the page to find out more about the circular economy, and how it could help you in the Maths and Science Challenge 2012.

www.mathsandscience2012.co.uk

Go online to watch these videos and find out more about careers in maths and science.

WHAT IS IT AND HOW WILL IT HELP US?

Designing systems

The circular economy is based on the understanding that systems can repair and restore themselves. In these systems, materials and energy flow endlessly without being wasted. For example, trees in a forest drop dead leaves, and these leaves provide nutrition for fungi and bacteria. The fungi and bacteria nourish the soil and the soil then nourishes the tree. So the system has changed the tree's waste into food that it can use.

These systems have a positive impact. Designers are now beginning to use these insights to design man-made products, materials and even cities to have a similar positive impact.

CHALLENGE 2012

GIVE YOUR VENUE A POSITIVE IMPACT

Turn waste into 'food'

Materials should never be thrown away or become waste. Materials need to be designed so that when they are no longer needed in their current use, they can provide 'food' for the next cycle.

This can be achieved in two ways. One option is to create materials that can decompose safely, and so nourish the soil. The alternative is to create materials that can be re-used again and again, circulating from business to business.

Think in systems

How do things connect and flow? What are all the consequences of our decisions? These are the questions we should be asking ourselves if we want to work in systems. As Zimbabwe's Eastgate Centre shows, nature can provide a lot of the answers.

Shift to renewables

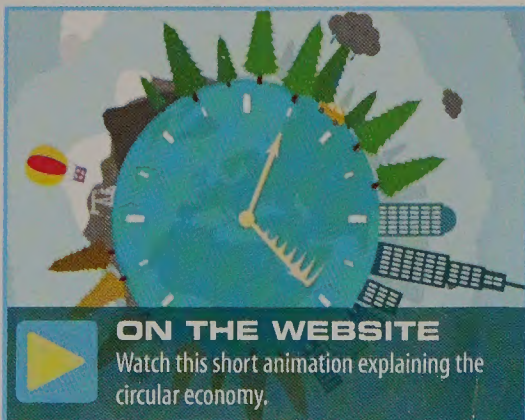
Fossil fuels are running out. It is essential that we move to renewable energies such as wind, solar and tidal. This has already started, but we still have a long way to go.



BIOMIMICRY'S COOL ALTERNATIVE: EASTGATE CENTRE IN HARARE

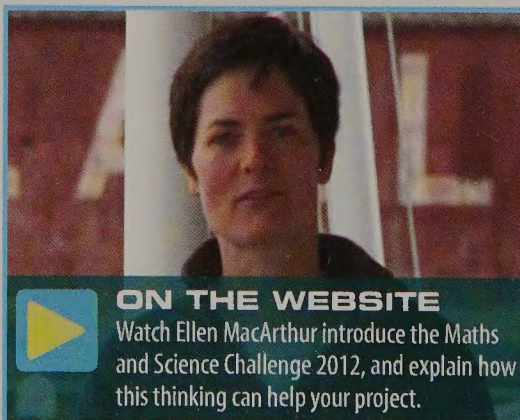
The Eastgate Centre in Harare is Zimbabwe's largest office and shopping complex. The building was designed by architect Mick Pearce and is one of the best examples of biomimicry – solving human problems by examining nature. It has no conventional air conditioning or heating, yet keeps a regular temperature all year round using very little energy.

It achieves this by mimicking the self-cooling mounds of African termites. Termite mounds include small tunnels that enable hot air from the main chambers below ground to be drawn up by the breeze. The hot air flows up through the mound and is released through vents at the top. The termites can regulate the temperature by opening or blocking the tunnels to control air flow. A similar method is used in the Eastgate Centre, as can be seen by the chimneys that line its roof.



ON THE WEBSITE

Watch this short animation explaining the circular economy.



ON THE WEBSITE

Watch Ellen MacArthur introduce the Maths and Science Challenge 2012, and explain how this thinking can help your project.

